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Methods

The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries

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Abstract – This paper describes early findings of evaluations of the International Caries Detection and Assessment System (ICDAS) conducted by the Detroit Center for Research on Oral Health Disparities (DCR-OHD). The lack of consistency among the contemporary criteria systems limits the comparability of outcomes measured in epidemiological and clinical studies. The ICDAS criteria were developed by an international team of caries researchers to integrate several new criteria systems into one standard system for caries detection and assessment. Using ICDAS in the DCR-OHD cohort study, dental examiners first determined whether a clean and dry tooth surface is sound, sealed, restored, crowned, or missing. Afterwards, the examiners classified the carious status of each tooth surface using a seven-point ordinal scale ranging from sound to extensive cavitation. Histological examination of extracted teeth found increased likelihood of carious demineralization in dentin as the ICDAS codes increased in severity. The criteria were also found to have discriminatory validity in analyses of social, behavioral and dietary factors associated with dental caries. The reliability of six examiners to classify tooth surfaces by their ICDAS carious status ranged between good to excellent (kappa coefficients ranged between 0.59 and 0.82). While further work is still needed to define caries activity, validate the criteria and their reliability in assessing dental caries on smooth surfaces, and develop a classification system for assessing preventive and restorative treatment needs, this early evaluation of the ICDAS platform has found that the system is practical; has content validity, correlational validity with histological examination of pits and fissures in extracted teeth; and discriminatory validity.

Key words: assessment; dental caries; diagnosis; reliability; validity

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Dental caries is a complex disease. Over the last several decades, a number of measurement criteria have been developed to identify the presence of dental caries. However, as the understanding of dental caries progressed, the clinical criteria systems remained focused on assessment the disease process at only one stage, the so called 'decayed' status. A recent review of 29 caries detection criteria systems concluded that the majority of the current caries detection systems were ambiguous and did not measure the disease process at its different stages (1). More recently several new

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criteria systems were proposed and evaluated (2–9). Again, these criteria systems vary in how the disease was measured (2).

In April and August 2002, a group of caries researchers, epidemiologists, and restorative dentists, met to integrate the different definitions. The group selected a 'foundation' for a new system based on the work of Ekstrand et al. (4), integrated the best features of the other systems (2–3, 5–8), and proposed a new system which was named the International Caries Detection and Assessment System (ICDAS). The group postponed including criteria to measure caries activity at the tooth surfaces level (9) because of the need for further evaluation.

In previous reports, we have described the philosophy and rationale for developing ICDAS (10–11). A summary is provided here. The impetus for developing ICDAS started during the International Consensus Workshop on Caries Clinical Trials (ICW-CCT) that was held in 2002 in Loch Lomond, Scotland, which concluded with the recommendation for the need to detect dental caries at the noncavitated stages (12). The consensus of the over 100 participants including researchers in the basic, clinical, and behavioral sciences related to dental caries concluded that '[for] future clinical trials recording only cavitated lesions, as an outcome measure is becoming outmoded' (12). Also, at that international workshop it was observed that there are several inconsistent detection systems of dental caries (1).

Three months after the ICW-CCT workshop, the first meeting of the ICDAS coordinating committee was held to develop 'a standardized system based on evidence from the best of what has gone before, should lead to better quality information to inform decisions about diagnosis, prognosis, and clinical management of dental caries at both the individual and public health levels' (11). ICDAS integrates several new criteria systems for caries detection (2–8). It was designed to detect six stages of the carious process, ranging form the early clinically visible changes in enamel caused by carious demineralization to extensive cavitation. ICDAS was divided into sections covering coronal caries (pits and fissures, mesial-distal, and buccal-lingual), root caries, and caries-associated-with-restorations-and-sealants (CARS). Also, the coordinating committee developed a full protocol for examination to ensure that that all conditions were specified in the criteria (for example, cleaning and drying of tooth surfaces).

What does ICDAS mean?

The 'D' in ICDAS stands for detection of dental caries by (i) stage of the carious process; (ii) topography (pit-and-fissure or smooth surfaces); (iii) anatomy (crowns versus roots); and (iv) restoration or sealant status. The 'A' in ICDAS stands for assessment of the caries process by stage (noncavitated or cavitated) and activity (active or arrested). The current version of ICDAS does not yet include an assessment of lesion activity. A clinical system for assessing lesion activity is being developed and will be added in the near future.

One important goal in developing ICDAS is to provide flexibility for clinicians and researchers to choose the stage of caries process and other features that fit the needs of their research or practice. Hence, the ICDAS committee developed the 'wardrobe' concept where the users can decide at what stage (noncavitated or cavitated) and severity they wish to measure dental caries. The only stipulation is the requirement that the ICDAS definitions are used for whatever stage of dental caries is chosen for a specific study.

The ICDAS criteria for assessing root caries have face validity but have not yet been tested in any epidemiological or clinical studies. Hence, this paper will only discuss the currently available data on content, correlational, and discriminate validity and reliability of the ICDAS criteria for assessing coronal caries.

ICDAS criteria for detection of caries on coronal tooth surfaces

The detection of dental caries on coronal tooth surfaces is a two-stage process. The first decision is to classify each tooth surface on whether it is sound, sealed, restored, crowned, or missing. The codes for the first decision are described in Table 1. Before describing the codes, it is important to define the term 'tooth surface'. In ICDAS, each tooth is divided into mesial, distal, facial, lingual and occlusal surfaces. Some tooth surfaces are further divided into sections. For example, for the maxillary molars there are occlusal-mesial and occlusal-distal sections that are divided by the transverse ridge. For mandibular molars the buccal pits are coded separately from smooth tooth surfaces. A similar division is also made between the lingual fissures and lingual smooth tooth surfaces of the maxillary molars and maxillary

Table 1. Decision number 1: classification of the restoration, sealant, or missing status in the International Caries Detection and Assessment System (ICDAS)

Code	Description
0	Un-restored or unsealed
1	Sealant, partial A sealant that does not cover all pits and fissures on a tooth surface
2	Sealant, full A sealant that covers all pits and fissure on a tooth surface
3	Tooth colored restoration In the opinion of the dentist, the tooth has a tooth colored (resin or glass–ionomer cement) 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	Tooth does not exist or other special cases. Used in as the following: 9–6 = Tooth surface cannot be examined because of access problem to visualize the tooth surface 9–7 = Tooth missing because of caries (all tooth surfaces are coded 97) 9–8 = Tooth missing for reasons other than caries (all tooth surfaces are coded 98) 9–9 = Un-erupted (all tooth surfaces care coded 99)

central incisors. In total, there are potentially 182 mutually exclusive tooth surfaces on the ICDAS examination form. As stated before, the configuration of surfaces chosen for use in any study and the stage used to measure dental caries may be determined for each study using the 'wardrobe' concept. For example, in a national study that aims to compare dental caries prevalence over time, the number and configuration of tooth surfaces may be selected to match previous surveys. Also, the stage of caries detection may be adjusted to match previous studies conducted in a country. Additional research is needed to figure out how the 'decayed' classification in the standard criteria systems correlates with the ICDAS criteria.

For the first decision in ICDAS, the criteria differentiate between fully and partially sealed tooth surfaces. There is evidence that partially sealed tooth surfaces may be at a higher risk of developing caries compared with sound or fully sealed teeth (6). The coding scheme also differentiates between tooth-colored and amalgam restorations, and among different types of crowns. Lost or broken restorations and teeth that have temporary restorations are also coded separately. Finally, a code of '9' is reserved for missing or unerupted tooth and special conditions such as exclusion from examination. The second number that comes after the code '9' indicates specific condition. For example, the code 9-6 is used to indicate that the examiner could not access a specific tooth surface in order to make a decision, and the code 9-7 is used to code teeth missing because of caries.

The second decision that should be made for each tooth surface is the classification of the carious status on an ordinal scale (Table 2). Tooth surfaces may be sound, or have a 'first visual change in enamel' (ICDAS code 1) which is defined differently for pits and fissures from the same condition on smooth tooth surfaces (Table 2). At this stage of dental caries on occlusal surfaces, 55% of the lesions are either sound or confined to enamel, and 45% are in the outer one-third of dentin (4). On smooth tooth surfaces, these lesions are only seen clinically when the tooth surface is dry, and they cannot be seen *in vivo* when the surface is wet with saliva. Detailed description of the criteria can be found in the proceedings of the 2005 Indiana Conference (10).

The next stage is called 'distinct visual change' (ICDAS code 2). At this stage, the lesion is noncavitated and can be seen when the tooth surface is wet with saliva. On pits and fissure, these lesions are wider than the confines of the pit or fissure area. The majority of these lesions either extend to the pulpal half of enamel or into the outer third of dentine (4). When a tooth surface shows signs of localized enamel breakdown because of caries with no visible dentin or underlying shadow, the caries process has advanced to stage 3 (ICDAS code 3).

The next ICDAS code (code 4) represents those lesions where there are underlying shadows indicating that the carious demineralization has progressed into dentin, the dentin is discolored, and the enamel surface is un-supported by the dentin (ICDAS code 4). If the cavitation exposes dentin, then the carious process has progressed into a stage referred to as 'distinct cavitation' (ICDAS code 5). A cavity that destroys at least one half of a tooth surfaces is referred to as 'extensive' (ICDAS code 6).

A concern here is the reliance on correlational data with histological examinations of occlusal surfaces (4). As will be discussed in the section entitled 'validity', the major source of information we have on validity of caries measurement both for the traditional systems and ICDAS is very limited and focuses only on information related to

Table 2. Decision number 2: classification of the carious status based upon the International Caries Detection and Assessment System (ICDAS)*

Sound tooth surface: Code 0

There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying (suggested drying time 5 s). Surfaces with developmental defects such as enamel hypoplasias; fluorosis; tooth wear (attrition, abrasion and erosion), and extrinsic or intrinsic stains will be recorded as sound. The examiner should also score as sound a surface with multiple stained fissures if such a condition is seen in other pits and fissures, a condition which is consistent with noncarious habits (e.g. frequent tea drinking). Table 1 provides a useful guide for differential diagnosis for carious opacities versus other opacities

First visual change in enamel: Code 1

Code 1: Pits and fissures

When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying (approximately 5 s is suggested to adequately dehydrate a carious lesion in enamel) a carious opacity or discoloration (white or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel

OR

When there is a change of color because of caries which is not consistent with the clinical appearance of sound enamel and is limited to the confines of the pit and fissure area (whether seen wet or dry). The appearance of these carious areas is not consistent with that of stained pits and fissures as defined in code 0

Code 1: Smooth tooth surfaces

When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying a carious opacity (white or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel. This will be seen from the buccal or lingual surface

Distinct visual change in enamel: Code 2

The tooth must be viewed wet. When wet there is a (i) carious opacity (white spot lesion) and/or (ii) brown carious discoloration which is wider than the natural fissure/fossa that is not consistent with the clinical appearance of sound enamel (Note: the lesion must still be visible when dry)

Localized enamel breakdown because of caries with no visible dentin or underlying shadow: Code 3

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 s there is carious loss of tooth structure at the entrance to, or within, the pit or fissure/fossa. This will be seen visually as evidence of demineralization [opaque (white), brown or dark brown walls] at the entrance to or within the fissure or pit, and although the pit or fissure may appear substantially and unnaturally wider than normal, the dentin is NOT visible in the walls or base of the cavity/discontinuity.

If in doubt, or to confirm the visual assessment, the WHO/CPI/PSR probe can be used *gently across a tooth surface* to confirm the presence of a cavity apparently confined to the enamel. This is achieved by sliding the ball end along the suspect pit or fissure and a limited discontinuity is detected if the ball drops into the surface of the enamel cavity/discontinuity

Underlying dark shadow from dentin with or without localized enamel breakdown: Code 4

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). The shadow appearance is often seen more easily when the tooth is wet. The darkened area is an intrinsic shadow which may appear as grey, blue or brown in color. The shadow must clearly represent caries that started on the tooth surface being evaluated. If in the opinion of the examiner, the carious lesion started on an adjacent surface and there no evidence of any caries on the surface being scored then the surface should be coded '0'.

Distinct cavity with visible dentin: Code 5

Cavitation in opaque or discolored enamel exposing the dentin beneath.

The tooth viewed wet may have darkening of the dentin visible through the enamel. Once dried for 5 s there is visual evidence of loss of tooth structure at the entrance to or within the pit or fissure – frank cavitation. There is visual evidence of demineralization [opaque (white), brown or dark brown walls] at the entrance to or within the pit or fissure and in the examiner judgment dentin is exposed

The WHO/CPI/PSR probe can be used to confirm the presence of a cavity apparently in dentin. This is achieved by sliding the ball end along the suspect pit or fissure and a dentin cavity is detected if the ball enters the opening of the cavity and in the opinion of the examiner the base is in dentin. (In pits or fissures the thickness of the enamel is between 0.5 and 1.0 mm. Note the deep pulpal dentin should not be probed)

Extensive distinct cavity with visible dentin: Code 6

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

*A description of the criteria as they apply to mesial-distal and buucal-lingual tooth surfaces is available in http://www.dundee.ac.uk/dhsru/news/icdas.htm.

occlusal surfaces. The quality of evidence on validity of the visual/tactile criteria currently in use in epidemiological studies has been judged to be poor (13).

Validity of the ICDAS

There are two types of validation methods. The first is based on qualitative assessment of whether a criteria system measures the disease process of dental caries. Another measure of content validation is whether the definitions used measure signs or characteristics of dental caries for the selected stage. While all criteria systems seek to measure similar characteristics, there is some significant variation among them (1). ICDAS was designed to meet the following concepts for content validity (1): (i) measure stages of the carious process rather than just the 'decayed' stage; (ii) provide detailed exclusion criteria of noncarious lesions (staining, fluorosis, opacities; and (iii) define the terms and descriptions used to measure the caries process.

Another method to validate caries criteria is based on the quantitative correlation between the clinical assessment of tooth surfaces with histological presence or extent of demineralization in enamel and dentin (4, 7). This correlational method of validation is fraught with problems. The major one is that it relies on evaluation of signs of caries in extracted teeth. The second is the variation that exists in the 'gold standard' because assessment of tooth sections could be subjective; dependent on which section of a tooth surface is being examined, and on the examiners' ability to identify signs of demineralization in histological sections.

The current and some of the new criteria systems have been evaluated for their ability to discriminate (3, 6, 8–9) between groups with different exposures to risk factors or preventive regimens. The traditional systems of caries assessment have extensive data on discriminatory validity. The criteria systems currently in use serve as the foundation for the current knowledge base on the etiology, epidemiology, and management of dental caries.

In this paper we will evaluate the validity of ICDAS based on its content validity, correlational validity with histological examination, and discriminatory validity.

Content validity of ICDAS

Using the criteria defined by Ismail (1) to evaluate the content validity, ICDAS was designed to meet all of the proposed criteria. ICDAS measures the caries process at different stages. It will also include, in the near future, clinical criteria to differentiate between active and inactive carious lesions. ICDAS definitions describe in some details the clinical characteristic of each stage of the caries process as well as noncarious lesions that should be excluded (10).

Correlational validity of caries assessment on occlusal surfaces

The ICDAS criteria were evaluated for their correlation with histological examination of extracted teeth. During the development workshop of ICDAS, the participants examined the occlusal surfaces of 57 extracted teeth (2). The consensus of 20 experts in cariology and caries epidemiology defined the clinical status of the occlusal surfaces. Each of the experts examined all teeth independently. Afterwards, all participants reviewed each extracted tooth and enlarged colored photographs of each tooth surface and reached consensus on the caries classification. The teeth were kept in a moist environment; and at a later date sectioned and then scored by two evaluators using the scale of Ricketts et al. (7). After the direct examination, the histological sections were scored at the same time by two examiners using a 10× magnifying lens. The two examiners re-scored together 10 teeth to assess their reliability (>20% of all teeth examined) and agreed the second time on 8 of the 10 scores.

Using the codes of ICDAS described in Table 2, the examiners' likelihood ratios that a tooth classified with codes 2, 3, 4, or 5–6 had dental caries into the dentin detected histologically relative to a tooth classified with codes 0 or 1 were 6.5, 10.0, 11.4, and 13.0, respectively. These likelihood ratios are relatively high compared with the likelihood ratio (LR) of standard medical signs and symptoms (14). For example, in relation to heart attacks, an elevation in the ST segmentation on an electrocardiogram (ECG) has a LR of 11.2; while radiating pain to both arms has a LR of 7.1 (15).

Discriminant validity of ICDAS

Data collected by the Detroit Center for Research on Oral Health Disparities (DCR-OHD) have been used to evaluate risk models of dental caries. Findings from three separate published papers will be discussed in this review (16–18). The data on dental caries prevalence and severity reported in the published papers were collected by the DCR-

OHD following ICDAS. In addition to the dental caries data, the DCR-OHD assessed social, behavioral, and dietary risk indicators. Details on the design and methods used are available in other papers (16–18).

The recent findings using ICDAS show that the outcome measures assessed using ICDAS can discriminate between risk groups. For example, using dental caries data collected using ICDAS, Burt et al. (16) reported that caries prevalence in adults (average age was 29 years), was extensive, with 82.3% of the adults having at least one cavitated lesion. They also found that dental caries severity assessed using the D_1D_2MFS [noncavitated lesions (D_1), cavitated lesions (D_2), missing (M), and filled tooth surfaces] in both the bivariate analyses and in the regression models, was associated with the frequency of soft drink consumption and presence of gingival plaque deposits. The ICDAS criteria discriminated between groups on the basis of their different exposures to soft drinks as well as oral hygiene status.

In another published study, Tellez et al. (17) reported some new findings on the association between D_1D_2S (total number of untreated decayed tooth surfaces) and the number of churches (negative) and grocery stores (positive). They concluded these two factors are important neighborhood characteristics that may discriminate among adults with different levels of caries severity measured using ICDAS.

In another study using ICDAS, Finlayson et al. (18) investigated the association between early childhood caries (ECC) and maternal health beliefs, behaviors, and psychosocial factors. They reported that one-third of the children had ECC, and 20% had severe ECC, based upon the definition developed by NIDCR (19). The prevalence of ECC increased with the age and low parenting stress. Education and income were associated with low ECC prevalence. Maternal oral health fatalism and knowledge of children's hygiene needs were associated with ECC among preschool-aged children, and ECC was higher among younger children who had past restorative care.

These studies are some of the publications that describe findings and models using the ICDAS criteria. The new detection systems can discriminate among groups of children and adults with different exposure to risk factors. Further analyses are underway to investigate the risk factors or indicators associated with noncavitated versus cavitated carious lesions.

Reliability of ICDAS

The common metric used in dental epidemiology is the kappa coefficient computed using information from tooth surfaces (4, 9, 20). In this paper we present findings on the overall reliability of two sets of examiners who were trained and calibrated using ICDAS.

The inter- and intra-examiner reliability was assessed throughout two waves of data collection in 2002–03 and 2004–05. The examiners in the first wave were identified as B, L, SM, C; and the examiners in the second wave are B, L, SO, K. Two of the examiners (B and L) participated in both waves. A total of 292 and 338 paired assessments of subjects were conducted to estimate inter- and intra-examiner reliabilities in wave I and II, respectively. Collectively the examiners scored a total of 23 322 and 26 174 tooth surfaces to estimate their reliabilities in wave I and II, respectively.

For the first decision in the ICDAS coding scheme for the tooth status (e.g. missing, restoration, and sealant) and because the codes are nominal, we estimated reliability using un-weighted kappa coefficients. The kappa coefficients were calculated using Cohen's formula (21). For the second decision in the ICDAS coding scheme we estimated reliability using weighted kappa coefficients, which are more appropriate for ordinal scales (22).

Two weighting schemes (Cicchetti-Allison and Fleiss-Cohen) were used to compute the kappa coefficients (23, 24) because there are no standards to decide which weighting scheme is preferred. The reliability coefficients of the examiners in wave I are presented in Tables 3 and 4. On the first decision in the ICDAS system, the two main examiners (B and L) in wave I had intra-examiner kappa coefficients of 0.86 and 0.98. The weekend examiners (C and SM) had intra-examiner kappa coefficients of 0.83 and 0.94. The inter-examiner reliability coefficients between the two main examiners were 0.73 and between the other examiners ranged between 0.78 and 0.90. Data are not available to compare examiners L with examiner SM because of a conflict in scheduling.

For the second ICDAS decision wave I (Table 4), the intra-reliability kappa coefficients for the two main examiners (B and L) were 0.78 and 0.82. For the other examiners (C and SM), the intra-examiner reliabilities were 0.59 and 0.79. The inter-examiner reliability coefficients ranged between 0.63 and 0.75. For all these comparison, the Fleiss and Cohen (24)

Table 3. Kappa coefficients (±SE) for the first decision (sealant and restoration status of a tooth surface) of the International Caries Detection and Assessment System (ICDAS). Wave I examinations, 2002–03

	Examiner 2			
Examiner 1	B	C	L	SM
B	0.86 ± 0.02			
C	0.81 ± 0.02	0.94 ± 0.02		
L	0.73 ± 0.04	0.81 ± 0.03	0.98 ± 0.01	
SM	0.78 ± 0.03	0.90 ± 0.01	NA*	0.83 ± 0.03

*Data were not collected because of a scheduling conflict.

Table 4. Kappa coefficients (±SE) for the second decision (stage of dental caries) of the International Caries Detection and Assessment System (ICDAS). Wave I examinations, 2002–03

		Examiner 2			
Examiner 1		B	C	L	SM
B	Cicchetti-Allison (23)	0.82 ± 0.02			
	Fleiss-Cohen (24)	0.91 ± 0.01			
C	Cicchetti-Allison	0.64 ± 0.03	0.79 ± 0.04		
	Fleiss-Cohen	0.77 ± 0.04	0.83 ± 0.05		
L	Cicchetti-Allison	0.75 ± 0.03	0.63 ± 0.05	0.78 ± 0.03	
	Fleiss-Cohen	0.84 ± 0.03	0.73 ± 0.06	0.87 ± 0.03	
SM	Cicchetti-Allison	0.66 ± 0.04	0.65 ± 0.03		0.59 ± 0.05
	Fleiss-Cohen	0.79 ± 0.04	0.77 ± 0.03	NA*	0.64 ± 0.06

*Data were not collected because of a scheduling conflict.

Table 5. Kappa coefficients (±SE) for the first decision (sealant and restoration status of a tooth surface) of the International Caries Detection and Assessment System (ICDAS). Wave II examinations, 2004–05

	Examiner 2			
Examiner 1	B	L	SO	K
B	0.90 ± 0.01			
L	0.90 ± 0.01	0.81 ± 0.01		
S0	0.91 ± 0.01	0.92 ± 0.01	0.90 ± 0.01	
K	0.84 ± 0.02	0.94 ± 0.01	0.95 ± 0.01	0.95 ± 0.01

weighted kappa coefficients were higher than those using the Cicchetti-Allison weighting method (23).

In wave II, 791 (77.5%) of the 1021 families who were seen in wave I were re-examined. The examinations were conducted by the same two main examiners who participated in wave I and two additional new examiners. Training and quality assurance were conduced following the protocol developed in wave I.

The intra-examiner kappa coefficients on the first decision of ICDAS codes ranged between 0.81 and 0.95 (Table 5). The inter-examiner kappa coefficients ranged between 0.90 and 0.95. For the second ICDAS decision in wave II (Table 6), the intra-examiner weighted kappa coefficients ranged between 0.73 and 0.78. The inter-examiner kappa coefficients ranged between 0.68 and 0.76. Again, for all these comparisons, the Fleiss and Cohen (24) weighted kappa coefficients were higher than those computed using the Cicchetti and Allison (23) method.

Discussion

The ICDAS is an ambitious but highly needed undertaking. The first task in understanding any chronic and infectious disease is to define how it can be detected clinically. The dental community has been studying dental caries for over 100 years, and the lack of agreement on how to define and measure this condition may be perceived as unacceptable. The plea of G. V. Black in 1910 (25) 'for greater earnestness in the study of caries of the enamel in its relation to the practice of dentistry' has not been heeded throughout the 20th century.

Table 6. Kappa coefficients (±SE) for the second decision (stage of dental caries) of the International Caries Detection and Assessment System (ICDAS). Wave II examinations, 2004–05

Examiner 1		Examiner 2 B	L	SO	K
B	Cicchetti-Allison (23)	0.73 ± 0.02			
	Fleiss-Cohen (24)	0.81 ± 0.02			
L	Cicchetti-Allison	0.70 ± 0.02	0.75 ± 0.02		
	Fleiss-Cohen	0.79 ± 0.03	0.83 ± 0.02		
SO	Cicchetti-Allison	0.72 ± 0.02	0.74 ± 0.02	0.78 ± 0.02	
	Fleiss-Cohen	0.80 ± 0.02	0.83 ± 0.02	0.85 ± 0.02	
K	Cicchetti-Allison	0.68 ± 0.02	0.72 ± 0.02	0.76 ± 0.03	0.73 ± 0.02
	Fleiss-Cohen	0.76 ± 0.03	0.80 ± 0.02	0.85 ± 0.02	0.80 ± 0.02

We share Dr Black's vision that to understand dental caries we need to study its earliest stages.

The current data available on the validity and reliability of *coronal caries detection* using ICDAS show that the system meets the requirements of validity and reliability. More research will be needed on validity of the system on smooth tooth surfaces and reliability in different settings among different examiners. The data presented in this paper show that for the most common disease condition, pit-and-fissure caries, the system has correlational validity. Moreover, ICDAS has discriminatory validity and reliability when the overall severity is assessed in a population. The data presented in this paper indicate that even when used by examiners who had no previous experience in epidemiological dental examination, ICDAS has good to excellent reliability. The reliability coefficients reported in this paper are within the range of kappa coefficients, and in some cases higher, than the reliability coefficients reported for the three criteria systems (3–5) which formed the foundation for the ICDAS system. Ekstrand et al. (4) reported kappa coefficients ranging between 0.54 and 0.63 for inter-examiner reliability and 0.73 and 0.89 for intra-examiner reliability. Fyffe et al. (5) reported mean inter-examiner kappa coefficients for novice examiners that ranged between 0.47 and 0.53 for noncavitated carious lesions, and 0.64 and 0.66 for cavitated lesions. Ismail et al. (3) reported higher kappa coefficients (0.80–0.90) for inexperienced examiners who were trained by examining over 200 children before the start of that study. Chesters et al. (8) found that two trained Lithuanian examiners, new to clinical research, achieved kappa coefficients above 0.80 over an extended period.

The results presented in this paper show that the new ICDAS protocol could assist in the collection of data on past and current carious lesions classified by the degree of severity based on the histological extent of the disease. However, the current ICDAS criteria do not yet differentiate between active and in-active carious lesions. The ICDAS Coordinating Committee (refer to the Acknowledgement section) has had concerns about the reliability of a newly developed clinical activity assessment system (9) in the hands of nonexperts, and the requirement of that system (9) to use sharp explorers to detect surface 'roughness'. Nonetheless, the omission of clinical criteria for determining caries activity of a tooth surface is a weakness of the current ICDAS. Efforts are underway to evaluate and build on existing clinical systems for assessing lesion activity (9).

Data on the validity and reliability of the ICDAS criteria for detection of root caries are not yet available. However, we contend that the proposed ICDAS system for root surface lesions (10) may have several advantages over traditional methods because it combines detection with assessment of lesion activity.

In conclusion, the ICDAS collaborative team has developed useful, easy to use, and clearly defined criteria for clinical visual caries detection. The system has been shown to be reliable in detecting dental caries on coronal tooth surfaces, even when used by inexperienced dental examiners. However, ICDAS still lacks validated definitions of caries activity which currently limits its ultimate utility for clinical practice and reliability of caries detection on specific tooth surfaces, such as smooth approximal surfaces. Collaboration with developers of other criteria systems that assess lesion activity and treatment needs will hopefully allow the development of one integrated and international system for caries detection and assessment, which can facilitate evidence based management of the caries process, as well as clinical research and future systematic reviews in this area.

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