Appendix

Criteria Manual

International Caries Detection and Assessment System (ICDAS II)

Workshop held in Baltimore, Maryland, March 12th-14th 2005
Sponsored by the National Institute of Dental and Craniofacial Research, the American Dental Association, and the International Association for Dental Research

Revised in December 2008 in Bogota, Colombia and in July 2009 in Budapest, Hungary

Author: International Caries Detection and Assessment System Coordinating Committee

Authorship of this report should be cited as follows: International Caries Detection and Assessment System (ICDAS) Coordinating Committee.

Members:

D. Banting
C. Deery
H. Eggertsson
K.R. Ekstrand
A. Ferreira Zanda
A.I. Ismail (co-chair)
C. Longbottom
S. Martignon
N. B. Pitts (co-chair)
E. Reich
D. Ricketts
R. Selwitz
W. Sohn
G. V. A. Douglas (formerly Topping) (coordinator)
D. Zero
This report summarizes the key decisions and clinical criteria which were discussed by the participants (Appendix) in the ICDAS II, which was held in Baltimore, Maryland, USA, on March 12 through 14, 2005. The workshop was funded by the National Institute of Dental and Craniofacial Research (NIDCR) and the American Dental Association (ADA). The International Association for Dental Research (IADR) provided administrative support for the workshop.

The objective of the workshop was to develop consensus on clinical caries detection criteria among experts in cariology, clinical research, restorative dentistry, pediatric dentistry, public health, biological sciences, and dental organizations. This goal was achieved by the end of the workshop. Additionally, the participants have (1) defined the stages the caries process that can portray the concept of demineralization at the non-cavitated stage as well as the caries process overall; and (2) defined clinically relevant validation methods and research agenda for the newly developed detection system. No definitive conclusion was reached regarding how to measure caries activity and research of this important concept will continue. The final outcome of the workshop was the revision of the ICDAS criteria developed in 2002. The new criteria for the detection and assessment of dental caries will be referred to as ICDAS II. The workshop participants concluded their deliberation by recognizing that the ICDAS system will continue to evolve as new information and tools are developed and validated. The ICDAS II presents a foundation upon which new caries assessment tools could be embedded to aid in making more accurate decisions for clinical practice as well as for clinical and epidemiological research. The ICDAS II system strives to achieve integration and coordination of the emerging field of caries assessment. Minor revisions have been made following in vivo and in vitro training exercises at an ICDAS meeting which took place in Bogota in December 2008.

**Coronal Primary Caries Detection Criteria**

**Overview**

The ICDAS detection codes for coronal caries range from 0 to 6 depending on the severity of the lesion. There are minor variations between the visual signs associated with each code depending on a number of factors including the surface characteristics (pits and fissures versus free smooth surfaces), whether there are adjacent teeth present (mesial and distal surfaces) and whether or not the caries is associated with a restoration or sealant. Therefore, a detailed description of each of the codes is given under the following headings to assist in the training of examiners in the use of ICDAS: Pits and fissures; smooth surface (mesial or distal); free smooth surfaces and caries associated with restorations and sealants (CARS). However, the basis of the codes is essentially the same throughout:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Sound</td>
</tr>
<tr>
<td>1</td>
<td>First Visual Change in Enamel (seen only after prolonged air drying or restricted to within the confines of a pit or fissure)</td>
</tr>
<tr>
<td>2</td>
<td>Distinct Visual Change in Enamel</td>
</tr>
<tr>
<td>3</td>
<td>Localized Enamel Breakdown (without clinical visual signs of dentinal involvement)</td>
</tr>
<tr>
<td>4</td>
<td>Underlying Dark Shadow from Dentin</td>
</tr>
<tr>
<td>5</td>
<td>Distinct Cavity with Visible Dentin</td>
</tr>
<tr>
<td>6</td>
<td>Extensive Distinct Cavity with Visible Dentin</td>
</tr>
</tbody>
</table>
Coronal Primary Caries Codes

Pits and fissures

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 seconds)). 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 non-carious 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 is assigned for the following 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 seconds 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 due to 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.

Distinct visual change in enamel: Code 2
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 (Note: the lesion must still be visible when dry).

Localized enamel breakdown due to 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 seconds 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 base and walls of the cavity are within enamel and dentin is NOT visible.

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 within a tooth surface area from a clinical view that is perpendicular to that surface.

Code 3 and 4, histologically may vary in depth with one being deeper than the other and vice versa. This will depend on the population and properties of the enamel. For example more translucent and thinner enamel in primary teeth may allow the undermining discoloration of the dentin to be seen before localized breakdown of enamel. However, in most cases code 4 is likely to be deeper into dentin than code 3.

**Distinct cavity with visible dentin: Code 5**
Cavitation in opaque or discolored enamel exposing the dentin beneath involving less than half of the tooth surface.

The tooth viewed wet may have darkening of the dentin visible through the enamel. Once dried for 5 seconds 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 dentin is exposed.

The WHO/CPI/PSR probe can be used to confirm the presence of a cavity 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 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**
Cavitation in opaque or discolored enamel exposing the dentin beneath involving at least half of the tooth surface.

Obvious loss of tooth structure and dentin is clearly visible on the walls and at the base in a cavity that involves at least half of the tooth surface.

**Smooth surface (mesial and distal)**
This requires visual inspection from the occlusal, buccal and lingual directions.

**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 seconds)). 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**.

**First visual change in enamel: Code 1**
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 when viewed wet: Code 2**
There is a carious opacity or discoloration (white or brown lesion) that is not consistent with the clinical appearance of sound enamel (Note: the lesion is still visible when dry). This lesion may be seen directly when viewed from the buccal or lingual direction. In addition, when viewed from the occlusal direction, this opacity or discoloration may be seen as a shadow confined to enamel, seen through the marginal ridge.

**Initial breakdown in enamel due to caries with no visible dentin: Code 3**
Once dried for approximately 5 seconds there is distinct loss of enamel integrity, viewed from the buccal or lingual direction. The base and walls of the cavity are within enamel and dentin is NOT visible.

If in doubt, or to confirm the visual assessment, the CPI probe can be used gently across the surface to confirm the loss of surface integrity.

**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 marginal ridge, buccal or lingual walls of enamel. This 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.

**Distinct cavity with visible dentin: Code 5.**
Cavitation in opaque or discolored enamel exposing the dentin beneath involving less than half of the tooth surface.

The WHO/CPI/PSR probe can be used to confirm the presence of a cavity in dentin. This is achieved by sliding the ball end along the surface and a dentin cavity is detected if the ball enters the opening of the cavity.

**Extensive distinct cavity with visible dentin: Code 6**
Cavitation in opaque or discolored enamel exposing the dentin beneath involving at least half of the tooth surface. Obvious loss of tooth structure, and dentin is **clearly visible** on the walls and at the base in a cavity that involves at least half of a tooth surface. The marginal ridge may or may not be present.
Free Smooth surface (buccal and lingual and direct examination of mesial and distal surfaces (with no adjacent teeth))

Sound tooth surface: Code 0
There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying (approximately 5 seconds)). 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.

First visual change in enamel: Code 1
When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying a carious opacity is visible that is not consistent with the clinical appearance of sound enamel

Distinct visual change in enamel when viewed wet: Code 2
There is a carious opacity or discoloration that is not consistent with the clinical appearance of sound enamel (Note: the lesion is still visible when dry). The lesion is located in close proximity (in touch or within 1 mm) of the gingival margin or adjacent to orthodontic or prosthetic attachments on a tooth surface.

Localized enamel breakdown due to caries with no visible dentin: Code 3
Once dried for approximately 5 seconds there is distinct loss of enamel surface integrity. The base and walls of the cavity are within enamel and dentin is NOT visible.

If in doubt, or to confirm the visual assessment, the WHO/CPI/PSR probe can be used with NO digital pressure to confirm the loss of surface integrity.

Underlying dark shadow from dentin with or without localized enamel breakdown: Code 4
This lesion appears as a shadow of discolored dentin visible through the enamel surface beyond the white or brown spot lesion, which may or may not show signs of localized breakdown. This appearance is often seen more easily when the tooth is wet and is a darkening and intrinsic shadow which may be grey, blue or brown in color.

Distinct cavity with visible dentin: Code 5
Cavitation in opaque or discolored enamel exposing the dentin beneath involving less than half of the tooth surface.

The WHO/CPI/PSR probe can be used to confirm the presence of a cavity in dentin. This is achieved by sliding the ball end along the surface and a dentin cavity is detected if the ball enters the opening of the cavity.

Extensive distinct cavity with visible dentin: Code 6
Cavitation in opaque or discolored enamel exposing the dentin beneath involving at least half of the tooth surface.
Obvious loss of tooth structure, and dentin is **clearly visible** on the walls and at the base in a cavity that involves at least half of a tooth surface. The marginal ridge may or may not be present.

Figure 1 depicts a simple decision tree for applying the 7-code for classifying coronal tooth surfaces following the ICDAS criteria.
Table 1. Differential Diagnosis between Milder Forms of Dental Fluorosis (Questionable, Very Mild, And Mild) and Nonfluoride Opacities of Enamel.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Milder Forms of Fluorosis</th>
<th>Nonfluoride Enamel Opacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area affected</td>
<td>Usually seen on or near tips of cusps or incisal edges.</td>
<td>Usually centred in smooth surface; may affect entire crown.</td>
</tr>
<tr>
<td>Shape of lesion</td>
<td>Resembles line shading in pencil sketch; lines follow incremental lines in enamel, form irregular caps on cusps.</td>
<td>Often round or oval.</td>
</tr>
<tr>
<td>Demarcation</td>
<td>Shades off imperceptibly into surrounding normal enamel.</td>
<td>Clearly differentiated from adjacent normal enamel.</td>
</tr>
<tr>
<td>Color</td>
<td>Slightly more opaque than normal enamel; paper-white. Incisal edges, tips of cusps may have frosted appearance. Does not show stain at time of eruption (in these milder degrees, rarely at any time).</td>
<td>Usually pigmented at time of eruption often creamy-yellow to dark reddish-orange.</td>
</tr>
<tr>
<td>Teeth Affected</td>
<td>Most frequent on teeth that calcify slowly (cuspids, bicuspids, second and third molars). Rare on lower incisors. Usually seen on six or eight homologous teeth. Extremely rare in deciduous teeth.</td>
<td>Any tooth may be affected. Frequent on labial surfaces of lower incisors. May occur singly. Usually one to three teeth affected. Common in deciduous teeth.</td>
</tr>
<tr>
<td>Gross hypoplasia</td>
<td>None. Pitting of enamel does not occur in the milder forms. Enamel surface has glazed appearance, is smooth to point of explorer.</td>
<td>Absent to severe. Enamel surface may seem etched, be rough to explorer.</td>
</tr>
<tr>
<td>Detection</td>
<td>Often invisible under strong light; most easily detected by line of sight tangential to tooth crown.</td>
<td>Seen most easily under strong light on line of sight perpendicular to tooth surface.</td>
</tr>
</tbody>
</table>

Figure 1. DECISION TREE FOR PRIMARY CORONAL CARIES DETECTION

Is there any visible signs of caries when the tooth has been cleaned and when viewed wet?

No

Dry tooth for long enough to dehydrate any possible lesion (approx 5s)

Is there any opacity / discolouration at the entrance to the fissure?

No

Code 0
Sound

Yes

Code 1
First visible sign of caries

Yes

Code 4

Is there undermining discolouration of the dentine – this is often seen better when wet?

Yes

Is there a microcavity or obvious cavity?

No

Is there a distinct opacity at the entrance to the fissure or slightly beyond?

Yes

Code 2
Microcavitation

No

Is dentine visible at the base of the cavity?

Yes

Is more than half of the crown involved in caries?

Yes

Code 5

No

Code 6

Yes
Caries-Associated with Restorations and Sealants (CARS) Detection Criteria

Caries Associated with Restorations and Sealants Codes

Sound tooth surface with restoration or sealant: Code 0
A sound tooth surface adjacent to a restoration/sealant margin. There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying for 5 seconds). Surfaces with marginal defects less than 0.5mm in width (i.e. will not admit the ball end of the CPI Probe), developmental defects such as enamel hypoplasias; fluorosis; tooth wear (attrition, abrasion and erosion), and extrinsic or intrinsic stains will be recorded as sound. Stained margins consistent with non-caries habits (e.g. frequent tea drinking) and which do not exhibit signs consistent with demineralization should be scored as sound.

First visual change in enamel: Code 1
When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying (for approximately 5 seconds) an opacity or discoloration consistent with demineralisation is visible that is not consistent with the clinical appearance of sound enamel.

Distinct visual change in enamel/dentin adjacent to a restoration/sealant margin: Code 2
- If the restoration margin is placed on enamel the tooth must be viewed wet. When wet there is an opacity consistent with demineralisation or discoloration that is not consistent with the clinical appearance of sound enamel (Note: the lesion is still visible when dry).
- If the restoration margin is placed on dentin: Code 2 applies to discoloration that is not consistent with the clinical appearance of sound dentin or cementum.

Carious defects of <0.5 mm with the signs of code 2: Code 3
Cavitation at the margin of the restoration/sealant less than 0.5mm, in addition to either an opacity or discoloration consistent with demineralisation that is not consistent with the clinical appearance of sound enamel or with a shadow of discolored dentin.

Marginal caries in enamel/dentin /cementum adjacent to restoration/sealant with underlying dark shadow from dentin: Code 4
The tooth surface may have characteristics of code 2 and has a shadow of discolored dentin which is visible through an apparently intact enamel surface or with localized breakdown in enamel but no visible dentin. This appearance is often seen more easily when the tooth is wet and is a darkening and intrinsic shadow which may be grey, blue, orange, or brown in color. Note: view tooth wet and then dry. This lesion should be distinguished from amalgam shadows.
Distinct cavity adjacent to restoration/sealant: Code 5

Distinct cavity adjacent to restoration/sealant with visible dentin in the interfacial space with signs of caries as described in code 4, in addition to a gap > 0.5mm in width.

OR

In those instances where margins are not visible, there is evidence of discontinuity at the margin of the restoration/sealant and tooth substance of the dentin as detected by 0.5mm ball-ended probe run along the restoration/sealant margin.

Distinct cavity adjacent to restoration/sealant with visible dentin in the interfacial space with signs of caries as described in code 4, in addition to a gap > 0.5mm in width.

Extensive distinct cavity with visible dentin: Code 6

Obvious loss of tooth structure, the extensive cavity may be deep or wide and dentin is clearly visible on both the walls and at the base.

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, for example a tooth restored with amalgam which also exhibited an extensive distinct cavity with visible dentin would be coded 4 (for an amalgam restoration) 6 (distinct cavity), an unrestored tooth with a distinct cavity would be 06. The suggested restoration/sealant coding system is as follows:

0 = Sound: i.e. 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 (porcelain fused to metal crown) crown or veneer or inlay or onlay or other restorative material
7 = Lost or broken restoration
8 = Temporary restoration
9 = Used for the following conditions

90 = Implant for other non-carious related reasons
91 = Implant placed due to caries
92 = Pontic placed for reasons other than caries
93 = Pontic placed for carious reasons
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)

Further considerations (Guidelines of ICDAS in Epidemiology and Clinical Research setting)

In case of doubt the examiner should score low.
Non-vital teeth should be scored in the same manner as vital teeth.

Banded or bracketed teeth. All visible surfaces should be examined as well as possible and scored in the usual manner. When a surface is completely covered by a band or bracket and there is no evidence of caries the tooth status code is “0”.

In the case of supernumerary teeth, the examiner should decide which tooth is the legitimate occupant of the space. Only that tooth should be scored.

When both a primary and permanent tooth occupy the same space, only the permanent tooth is coded.

Where more than one carious lesion exists on a surface, the worst lesion should be scored, though scoring pits and fissures separately to free smooth surfaces is an option.

Whenever both the coronal and root surface are affected by a single carious lesion that extends at least 1 mm or more past the CEJ in both cervical-incisal and cervical-apical directions, both surfaces should be scored separately. For a lesion affecting both crown and root surfaces with extension from the CEJ of less than 1 mm, only that surface of tooth with the greater portion (more than 50%) of the lesion involvement should be scored. When it is impossible to invoke the 50% rule (i.e., when both coronal and root surfaces appear equally affected), both surfaces should be scored as carious.

All tooth surfaces of retained roots should be scored as (06).

If part of a restoration is lost on a surface, the surface should be coded as “7” (first number), even when not all the restoration is missing.

It is important that there is a code to record the instances where there are non-carious cavities, i.e. where a restoration has been lost. It could be argued that such cases are analogous with temporary restorations although it is the convention in some epidemiological studies to record these in a way that means that they are recorded within the “filled” rather than “decayed” element of the study findings.

A root surface adjacent to a crown margin that is free of decay should be scored sound.

If more than one lesion is present on the same root surface, the most severe lesion is scored.

### Root Caries Criteria

**Codes for the detection and classification of carious lesions on the root surfaces**

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. Removal of calculus is recommended for clinical trials and longitudinal studies.

**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 cemento-enamel junction or wholly on the root surface. The root surface has a natural anatomical contour, OR

The root surface may exhibit a definite loss of surface continuity or anatomical contour that is not consistent with the dental caries process. This loss of surface integrity usually is associated with dietary influences or habits such as abrasion or erosion. These conditions usually occur on the facial surface. These areas typically are smooth, shiny and hard. Abrasion is characterized by a clearly defined outline with a sharp border, whereas erosion has a more diffuse border. Neither condition shows discoloration.

**Code 1**
There is a clearly demarcated area on the root surface or at the cemento-enamel junction (cej) that is discoloured (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 cemento-enamel junction (cej) that is discoloured (light/dark brown, black) and there is cavitation (loss of anatomical contour ≥ 0.5 mm) present.

The following diagram (Figure 2) will serve as a useful prompt for examiners in deciding on appropriate coding of root caries:
Caries associated with root restorations

When a root surface is filled and there is caries adjacent to the restoration, the surface is scored as caries. The criteria for caries associated with restorations on the roots of teeth are the same as those for caries on non-restored root surfaces.

The following diagram (Figure 3) will assist the examiner in deciding on the appropriate coding of caries adjacent to restorations on root surfaces:

![Decision tree for caries associated with root restorations](image)

**Figure 3. Decision tree for caries associated with root restorations**
**Root caries activity**

The characteristics of the base of the discolored area on the root surface can be used to determine whether or not the root caries lesion is active or not. These characteristics include texture (smooth, rough), appearance (shiny or glossy, matte or non-glossy) and perception on gentle probing (soft, leathery, hard). Active root caries lesions are usually located within 2mm. of the crest of the gingival margin.

The following diagram (Figure 4) will be helpful in making a determination regarding the activity of root caries:

![Decision Tree for Root Caries Activity](image)

**Figure 4. Decision tree for root caries activity**

**Special considerations**

Whenever both a coronal and root surface are affected by a single carious lesion that extends at least 1 mm past the CEJ in both the incisal and apical directions, both surfaces should be scored as caries. However, for a lesion affecting both crown and root surfaces that does not meet the 1 mm or greater extent of involvement, only the coronal or root surface that involves the greater portion (more than 50%) of the lesion should be scored as caries. When it is impossible to invoke the 50% rule (i.e., when both coronal and root surfaces appear equally affected), both surfaces should be scored as caries.

When a carious lesion on a root surface extends beyond the line angle of the root to involve at least 1/3 of the distance across the adjacent surface, that adjacent surface also should also be scored as caries.

If more than one lesion is present on the same root surface, the most severe lesion is scored.

Non-vital teeth are scored the same as vital teeth.
ICDAS Caries Lesion Activity Assessment

**Working Definitions**

An **Active Lesion** is considered to have a greater likelihood of transition (progress, arrest or regress) than an inactive lesion.

An **Inactive (arrested) Lesion** is considered to have a lesser likelihood of transition than an active lesion.

Clinical observations to be taken into consideration for assessing enamel lesion activity are based on a modification of the Nyvad et al. (1999) caries lesion activity assessment criteria and include visual appearance, tactile feeling and potential for plaque accumulation.

<table>
<thead>
<tr>
<th>ICDAS Code</th>
<th>Characteristics of Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active Lesion</strong></td>
<td><strong>Inactive Lesion</strong></td>
</tr>
<tr>
<td>1, 2 or 3</td>
<td>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. Lesion is in a plaque stagnation area, i.e.: pits and fissures, near the gingival and approximal surface below the contact point.</td>
</tr>
<tr>
<td>4</td>
<td>Probably active</td>
</tr>
<tr>
<td>5 or 6</td>
<td>Cavity feels soft or leathery on gently probing the dentin.</td>
</tr>
</tbody>
</table>
Recommendations for Examiner Training

The ICDAS committee recommends the following training program:

One half day of slide presentations and discussions of the ICDAS codes and protocol for examination.

At least 2 days of examiner training which will include examination of a set of subjects providing balanced numbers of tooth surfaces with ICDAS codes 1-5. The examination findings of all examiners should be reviewed to identify differences in interpretation. Examinations are to be repeated until agreement is reached among the examiners. This exercise should be conducted by a “senior examiner”. Part of the exercise may involve using extracted teeth; however, the training exercise must include examining live subjects.

Two days of reliability assessment using live subjects presenting with carious lesions with severity ranging between 1 and 5 (ICDAS). At least 20 patients should be examined per examiner and the “senior examiner”.

A senior examiner is a dentist with experience in using the ICDAS, has high degree (Kappa = 0.75+) of intra-examiner reliability, and has been calibrated and is reliable with another experienced ICDAS examiner (Kappa=>0.65+). In some studies, a senior examiner may work concurrently with the other examiners to reach a final decision. The term “senior examiner” is used to refer to the standard which will be used to compare with the findings of the examiners in a study. The report of a study should provide details on the calibration exercise and the senior examiners(s).

Agree standard trainees need to reach kappa at least equal to 0.65+

Statistical Consideration for Analysis of the Reliability of ICDAS

The conventional method of analysis of reliability data has been to present aggregate kappa coefficients for either each examiner or all examiners participating in a study. Kappa coefficients have the following advantages over simple percent agreements: 1) they account for agreement by chance alone for binary and nominal ratings [Maclure and Willett, 1987], and 2) there are standards for evaluating the strength of the agreement using this method. However, kappa analyses have disadvantages as well. Kappa is more a measure of exact agreement instead of being a measure of the degree of approximate agreement [Maclure and Willett, 1987]. A simple kappa coefficient does not distinguish between the different sources and magnitudes of disagreement. This measure of agreement tends to treat all the cases of disagreement alike however large or small they might be [Maclure and Willett, 1987]. In other words, kappa does not consider the degree of disagreement between observers. Kappa may not be comparable across different studies as the statistic is influenced by trait prevalence or distribution and the disease categories [Spitznagel et al., 1985; Thompson et al., 1988a and 1988b; Feinstein et al., 1990]. The presence of bias between observers and the variations in the distribution of data across the categories may cause computational and interpretation problems in a kappa analysis [Byrt et al., 1993].
When continuous data are categorized to form ordinal categories, kappa becomes arbitrary and virtually meaningless [Maclure and Willet, 1987]. Sometimes the examiners may be consistent, but the kappa statistic may not display this agreement due to large number of categories, lack of marginal homogeneity or marginal distribution of the data. In such cases, other flexible approaches like statistical modelling may have to be used [Uebersax, 1987a and 1987b].

In order to account for the degree of disagreement between observers and also to distinguish the disagreements, weighted kappa may be used. This statistic incorporates the factor of agreement by chance alone and also has a feature of weighted proportional agreement. This is obviously an improved measure over the simple Cohen’s kappa, but the use of standard weights makes the new statistic of weighted kappa equivalent to intraclass correlation coefficient [Fleiss et al., 1973].

One important requirement for testing whether the kappa coefficients are statistically accurate is to test for marginal homogeneity of the distribution of codes for each examiner. Marginal homogeneity [Barlow, 1998; Bishop et al., 1975] means that the marginal frequencies or proportions of one or more categories are the same for both examiners. The Stuart-Maxwell (SM) statistic tests the homogeneity of marginal frequencies and is interpreted like a chi-squared test [Uebersax, 2005].

If the marginal distributions are not homogenous, then the kappa coefficients may not be accurate and may lead to erroneous conclusions. In such case, we recommend using other methods for analysis of reliability data. Log-linear modelling provides another approach for analysis of examiners’ reliability [Uebersax, 1993; Kingman, 1986]. This approach is quite flexible in its assumptions of the distributions of the codes assigned by the examiners to tooth surfaces. Further, the general framework allows for simultaneous incorporation of multiple (more than two) examiners, each rating an arbitrary number of categories. Hence, the symmetry of categories required for computing the kappa coefficients is not required for log linear models [Tanner, 1985].

The users of ICDAS should provide the following reliability statistics.
- Kappa coefficients for comparisons between the senior examiner and each examiner separately.
- Kappa coefficients for intra-examiner reliability for each examiner.
- Rows X Columns table should be included for all comparisons.

If possible, it is recommended that SM tests are also performed. However, computing the SM tests requires some advanced programming skills.
References


APPENDIX

PARTICIPANTS IN THE ICDAS BALTIMORE WORKSHOP
(Upon the request of Federal Officials and one participant, their names were deleted)

Coordinators

Amid Ismail
Professor
School of Dentistry, University of Michigan
Ann Arbor, MI 48109-1078
USA
T: 734-647-9190
F: 734-936-1597
ismailai@umich.edu

Gail Topping
Director of Dental Caries Control Programme/Honorary Consultant in Dental Public Health
Dental Health Services Research Unit
University of Dundee
Telephone: +44(0)1382 420050 (Secretary Hazel Braid)
Mobile phone: +44(0)7962 211219
Fax: +44(0)1382 420051
g.topping@chs.dundee.ac.uk

Students:

Khalifa Sulaiman Al-Khalifa (University of Michigan)
Adjunct Clinical Assistant professor, Cariology, Restorative Sciences, and Endodontics
2361 Dent, Ann Arbor, MI 48109-1078
Tel: 734 647 4182
khalifaa@umich.edu

Fang Gu (University of California)
fanggu@ucla.edu

Sonia Kumari Makhija (University of Alabama)
Department of Diagnostic Sciences,
Post-doctoral Fellow and Clinical Instructor at the University of Alabama at Birmingham
School of Dentistry, Birmingham, AL
drmsmak2003@yahoo.com

Stefania Martingnon (Universidad El Bosque, Colombia)
PhD Candidate, University of Copenhagen, Denmark
smartignon@yahoo.com
Stefania Martignon (Universidad El Bosque, Colombia)  
PhD Candidate, University of Copenhagen, Denmark  
smartignon@yahoo.com

Participants:

Jim Bader  
Research Professor, Dept. of Operative Dentistry &  
Senior Fellow, Sheps Center for Health Services Research  
University of North Carolina  
725 Airport Rd  
Chapel Hill NC 27514  
tel: 919-966-5727  
fax:919-966-3811  
jim_bader@unc.edu

David Banting  
School of Dentistry  
Faculty of Medicine & Dentistry  
University of Western Ontario  
London, ON N6A 5C1  
Telephone: 519-661-2111 x86130  
Fax: 519-661-3875  
dbanting@uwo.ca

Richard Chesters  
Director Oral Care Professional Relations  
Colgate-Palmolive Europe  
13-15, Cours de Rive  
1204 Geneva  
Switzerland  
Tel No. +41 22 722 0784  
Fax No. +41 22 722 0703  
Mobile: +41 79 596 3956  
Richard_Chesters@colpal.com

Chris Deery  
Consultant in Paediatric Dentistry  
Edinburgh Dental Institute  
Lauriston Building  
3 Lauriston Place  
Edinburgh  
EH3 9YW  
Tel:44 (0)131 536 4994  
Fax:44 (0)131 536 4908  
Chris.deery@lpct.scot.nhs.uk
Elbert de Josselin de Jong
Chief Research
Inspektor Research Systems
Quellijnstraat 92
1072 XX Amsterdam
The Netherlands
T: +31 20 676 4988
F: +31 20 679 3183
e.dejosselindejong@inspektor.nl

Kenneth A. Eaton
United Kingdom
Tel/Fax: ++ 44 1233 813585
K.Eaton@eastman.ucl.ac.uk or keaton@rcseng.ac.uk

Hafsteinn Eggertsson
Assistant Professor
Indiana University School of Dentistry
Oral Health Research Institute
415 Lansing Street
Indianapolis, IN 46202-2876
USA
317-278-3457
317-274-5425
heggerts@iupui.edu

Frederick Eichmiller
ADAF Paffenbarger Research Center
100 Bureau Drive, MS 8546
Gaithersburg, MD 20899-8546
Tel: 301-975-6813
Fax: 301-963-9143
Fred Eichmiller fred.eichmiller@nist.gov

Kim Ekstrand
Associate Professor of Cariology and Endodontics
Dentistry Faculty of Health Sciences,
University of Copenhagen
20 Noerre Allé
DK-2200 Copenhagen N Denmark
T: 45 35326813
F: 45 35326505
kim@odont.ku.dk

Augusto R. Elias-Boneta
University of Puerto Rico School of Dentistry
PO Box 365067
San Juan, PR 00936-5067  
Telephone: (787) 765-3379  
Fax: (787) 763-4868  
aelias@rcm.upr.edu

Roger P Ellwood  
Dental Health Unit  
Skelton House  
Lloyd St North  
Manchester M15 6SH  
0161-232-4705 phone  
0161-232-4700 fax  
roger.ellwood@manchester.ac.uk

John D. B. Featherstone  
Professor and Chair  
Department of Preventive and Restorative Dental Sciences 
University of California San Francisco  
PO Box 0758, 707 Parnassus Ave  
San Francisco, CA 94143-0758  
Telephone 415-476-0456  
Fax 415-476-0858  
jdbf@itsa.ucsf.edu

Andrea G. Ferreira Zandona  
Assistant Professor  
Oral Health Research Institute  
Indiana University School of Dentistry  
Department of Preventive and Community Dentistry  
415 Lansing Street, Room 129  
Indianapolis, IN 46202  
USA  
317-274-3409  
317-274-5425  
azandona@iupui.edu

Rainer Haak  
University of Cologne  
Centre of Dental Medicine  
Dept. of Operative Dentistry and Periodontology  
Kerpener Str. 32  
D-50931 Köln  
Tel.: +49 (0)221 478-4124; -4710 (Secretary Herbert Stecher)  
Fax: +49 (0)221 478-6405  
Rainer.Haak@medizin.uni-koeln.de  
<http://www.medizin.uni-koeln.de/kliniken/zahn/erhalt/>
Andrew Hall  
Senior Lecturer in Restorative Dentistry,  
Glasgow University Dental School  
378 Sauchiehall Street,  
Glasgow,  
G2 3JZ,  
Scotland, UK  
Tel: (44) 141 211 9778  
Fax: (44) 141 331 2798  
a.hall@dental.gla.ac.uk

Marie-Charlotte Huysmans  
Division of Conservative Dentistry  
Dept. of Dentistry and Dental Hygiene  
GUMC  
University of Groningen  
A. Deusinglaan 1  
NL-9713 AV Groningen  
The Netherlands  
tel: 31.50.363.3203  
fax: 31.50.363.2696  
m.c.d.n.j.m.huysmans@med.rug.nl

Edwina Kidd (married name Littleton)  
Retired Professor, University of London

Justine Kolker  
University of Iowa

Jessica Y. Lee  
Assistant Professor  
Depts of Pediatric Dentistry and Health Policy Analysis  
228 Brauer Hall, CB #7450  
University of North Carolina at Chapel Hill  
Chapel Hill, NC 27599-7450  
Phone 919-966-2739  
Fax 919-966-7992  
Jessica_Lee@dentistry.unc.edu

Steven Levy  
Professor, College of Dentistry  
University of Iowa  
N330 DSB  
Iowa City, IA 52242  
319-335-7185(phone)  
319-335-7187(FAX)  
steven-levy@uiowa.edu
Chris Longbottom  
Senior Lecturer in Preventive & Children's Dentistry, Dundee Dental School  
Programme Methodologist, Dental Health Services Research Unit, University of Dundee  
9th Floor  
University of Dundee Dental School  
Park Place  
Dundee, DD1 4HN  
UK  
44 (0)1382 425 759  
44 (0)1382 206 321  
c.longbottom@dundee.ac.uk

Daniel Meyer  
Associate Executive Director  
Director, Division of Science  
American Dental Association  
211 E. Chicago Ave.  
Chicago, IL 60611-2678  
Tel: 312-440-2543  
meyerd@ada.org

Athena S. Papas  
Johansen Professor of Dental Research  
Tufts School of Dental Medicine  
1 Kneeland St  
Boston, Mass. 02111  
617-636-3932  
Fax 617-636-4083  
Athena.Papas@tufts.edu

Deok-Young Park  
Associate Professor  
Department of Preventive and Public Health Dentistry,  
College of Dentistry, Kangnung National University  
123 Jibyeon-dong, Kangnung-shi,  
Kangwon-do 210-702,  
South Korea  
Phone: +82-640-3185  
Cell Phone: +82-10-8988-7542  
FAX: +82-640-3103  
jguitar@kangnung.ac.kr

Neil Pender  
Senior Lecturer/Consultant in Orthodontics,  
Dept. of Clinical Sciences,  
The University of Liverpool,
Mathilde C. Peters  
Professor  
School of Dentistry, University of Michigan  
Ann Arbor, MI 48109-1078  
USA  
Tel: 734 763 3366  
mcpete@umich.edu

Klaus Pieper  
Professor  
Medizinisches Zentrum ZMK  
Georg-Voigt-Str. 3-5  
35033 Marburg, Germany  
Phone: +49 6421 2863224  
Fax: +49 6421 2866691  
pieper@med.uni-marburg.de

Nigel B. Pitts  
Professor  
Director, Dental Health Services Research Unit  
Honorary Consultant in Dental Public Health  
Dental Health Services Research Unit, University of Dundee  
The Mackenzie Building  
Kirsty Semple Way, Ninewells Hospital  
Dundee, DD2 4BF  
UK  
44 (0)1382 420 058  
44 (0)1382 420 051

Iain A Pretty  
Research Fellow  
Dental Health Unit  
University of Manchester  
Unit 3A, Skelton House  
Manchester Science Park  
Manchester M15 6SH, UK  
Telephone: 0161-226-1211  
Fax: 0161 226 1244  
iainbds1@tiscali.co.uk

Elmar Reich  
Rolf-Keller-Platz 1  
88400 Biberach  
Germany
ereich@t-online.de (EREich@t-online.de)

David Ricketts  
Senior Lecturer / Hon Consultant in Restorative Dentistry 
Dundee Dental School 
Park Place 
Dundee 
DD1 4HR  
United Kingdom  
Tel No 01382 660 111 Extension 35820  
Fax 01382 635984  
d.n.j.ricketts@dundee.ac.uk

Robert H. Selwitz (ICDAS Committee member: former official representative of NIDCR)
Formerly, 
Chief, Population Research and Health Promotion Branch 
Director, Residency Program in Dental Public Health 
Division of Clinical Research and Health Promotion 
Natcher Building, Room 4As-37J  
45 Center Drive MSC 6401  
Bethesda, MD 20892-6401  
Tel: 301-594-3977 
Fax: 301-480-8322  
robert.selwitz@nih.gov

Xie-Qi Shi (Birgit Angmar-Mansson) 
Department of Cariology and Endodontology 
Institute of Odontology 
Karolinska Institutet  
Box 4064  
SE 141 04 Huddinge  
Sweden  
Telephone: + 46 8 524 88184  
Fax: +46 8 711 83 43  
xie.qi.shi@ofa.ki.se

Dan Shugars  
Professor, School of Dentistry  
University of North Carolina, CB# 7450 
Chapel Hill, NC 27599-7450  
919-966-1214  
dan_shugars@dentistry.unc.edu
Richard J. Simonsen  
Associate Dean and Professor of Restorative Dentistry  
Arizona School of Dentistry & Oral Health  
5850 East Still Circle  
Mesa, AZ 85206  
480-219-6082-phone  
480-203-9195-cell  
480-219-6180-fax  
rsimonsen@atsu.edu

Woosung Sohn  
Assistant Professor  
School of Dentistry, University of Michigan  
Ann Arbor, MI 48109-1078  
USA  
T: 734-615-6622  
F: 734-936-1597  
woosung@umich.edu

George W. Taylor  
Associate Professor  
University of Michigan School of Dentistry  
Dept. of Cariology, Restorative Sciences & Endo  
1011 N. University  
Ann Arbor, MI 48109  
Phone: (734) 764-1737; FAX: (734) 936-1597  
gwt@umich.edu

Marisol Tellez  
Former Research Fellow  
University of Michigan School of Dentistry  
Dept. of Cariology, Restorative Sciences & Endo  
1011 N. University  
Ann Arbor, MI 48109  
Phone: (734) 615-7186; FAX: (734) 936-1597  
mwelcome@umich.edu

Van P. Thompson  
Biomaterials & Biomimetics  
NYU College of Dentistry  
345 E 24th St., 804S  
New York, NY 10010  
212-998-9638, FAX 212 995-4244  
vand.thompson@nyu.edu
Norman Tinanoff  
Department of Health Promotion and Policy  
University of Maryland Dental School  
666 W. Baltimore St.  
Baltimore, MD 21201  
Tel: 410 706 7970  
NTinanoff@dental.umaryland.edu

Monique H. van der Veen  
Senior Science Officer  
Inspektor Research Systems  
Quellijnstraat 92  
1072 XX Amsterdam  
The Netherlands  
T: +31 20 676 4988  
F: +31 20 679 3183  
m.vd.veen@inspektor.nl

Helen Whelton  
Director Oral Health Services Research Centre,  
Senior Lecturer in Dental Public Health and Preventive Dentistry,  
Department of Oral Health and Development,  
University Dental School and Hospital, Wilton, Cork  
tel +353 21 4901212  
fax +353 21 4545391  
H.Whelton@ucc.ie

Domenick T. Zero  
Associate Dean for Research  
Professor and Chair, Department of Preventive and Community Dentistry  
Director, Oral Health Research Institute  
Indiana University School of Dentistry  
Oral Health Research Institute  
415 Lansing Street  
Indianapolis, IN 46202-2876  
Phone: +1-317-274-8822  
Fax: +1-317-274-5425  
Mobile: +1-317-402-4607  
dzero@iupui.edu