Caries diagnosis: agreement between WHO and ICDAS II criteria in epidemiological surveys

J.E. Iranzo-Cortés, J.M. Montiel-Company and J.M. Almerich-Silla

Department of Stomatology, University of Valencia, Spain

Objective: The aim of this study was to ascertain the equivalence between WHO caries diagnosis criteria and the ICDAS II caries classification scale for comparisons in epidemiological studies. ***Materials and methods:*** Two intraoral examinations, one using the ICDAS II caries codes and the other the WHO caries assessment method, were performed in a random sample of 101 children (29 aged 5-6 years, 32 aged 12 and 40 aged 15). Both examinations were performed not more than one month apart by two calibrated examiners (one for ICDAS II criteria, Kappa=0.86, and the other for WHO criteria, Kappa=0.91). The DMFT/dft, DMFS/dfs and caries prevalence (DMFT or dfs>0) indices were obtained in accordance with WHO assessment criteria and by applying 5 cut-off points on the ICDAS II scale. The differences between means were analysed with the Wilcoxon test and those between proportions with the McNemar test. Agreement was determined by the intraclass correlation index and the Kappa statistic. ***Results:*** The least differences between the WHO and ICDAS II criteria were found at cut-off point 3 (ICDAS II codes 3 to 6). The greatest agreement was found at the same cut-off point. ***Conclusion:*** While the equivalence between both methods used in epidemiological studies does not appear to be clear, possible errors could be reduced by locating this equivalence at cut-off point 3 and not at cut-off point 4.

Key words: *caries detection, epidemiology, public dental health*

Introduction

In 2002, a multidisciplinary committee of cariology, radiology and histology experts devised a new caries diagnosis method, the International Caries Detection and Assessment System (ICDAS) which was then revised and extended in 2005 (ICDAS II). The ICDAS II codes classify six stages of caries, from the first white spot lesion in dry enamel (code 1) to extensive cavitation involving over half the tooth surface (code 6). This system has proved to be a comprehensive diagnostic tool equally valid with individuals in the surgery and with communities in epidemiological studies, as well as allowing comparison with the WHO indices (Braga *et al*., 2009b; Pine and Harris, 2007). To date, few epidemiological studies have used the ICDAS II system (Agustsdottir *et al*., 2010; de Amorim *et al*., 2012; Cadavid *et al*., 2010; Reisine *et al*., 2008)

The main problem with using ICDAS II for epidemiological studies is comparability, as most studies to date have been conducted with WHO caries assessment criteria and methods.

The need to compare caries indices and prevalence in order to ascertain epidemiological trends and plan health services has made it necessary to establish the equivalences between the ICDAS II scale of caries codes and the caries diagnosis criteria recommended by the WHO for epidemiological studies. Although ICDAS II locates this equivalence at code 4 (ICDAS a), authors such as Braga *et al*. (2009b) place it at code 3. This point is still a subject of debate.

Consequently, the main aim of this study was to ascertain the equivalence between the WHO caries diagnosis criteria and the ICDAS II scale of caries classification codes for the purpose of comparing epidemiological studies.

Materials and Methods

Two clusters (school classes) per cohort were selected at random from those taking part in the 2010 oral health survey of schoolchildren in the Valencia region of Spain, which was conducted in age cohorts of 5-6, 12 and 15 years.

Two intraoral examinations were carried out. The first was performed as part of that 2010 survey, which used the ICDAS II caries coding scale. The second examination of the same children was carried out not more than a month later, using the WHO caries diagnosis criteria. The study sample of 101 children consisted of 29 aged 5-6 years, 32 aged 12 and 40 aged 15.

The first examination was performed by an examiner calibrated to conduct the 2010 Valencia oral health survey using ICDAS II criteria and codes. This calibration consisted of a course in the Smile-On e-learning programme (ICDAS b) and calibration against a gold standard. To determine reliability, the 7 ICDAS II categories (codes 0, sound, and 1-6) were compared in 240 teeth across 10 children under the same conditions as in the study. The reliability of the different categories assessed by the Kappa statistic ranged from 0.51 to 0.89 and the overall agreement was high, with a linear weighted Kappa value of 0.86.

The second examination was carried out by a different examiner, who was calibrated in the WHO caries detection method. This examiner achieved high reliability (Kappa=0.91) in relation to an experienced examiner, act-

Correspondence to: José Manuel Almerich-Silla, Clínica Odontológica, Universitat de València, C/ Gascó Oliag 1, València (46010), Spain. Email: jose.m.almerich@uv.es

ing as the gold standard, who had taken part in several previous epidemiological studies in a comparison of the categories of sound or carious in a sample of 248 teeth across 10 children.

Permission to conduct this study was obtained from the Ethics Committee of the University of Valencia. The parents or guardians of the children to be examined were informed and signed consent forms. They were subsequently sent individual reports of the examination findings.

The examination instruments used were a WHO-type periodontal probe and a No.5 plane mouth mirror. A portable air compressor was carried to dry the teeth for the ICDAS II examination. New disposable latex gloves and face masks were used for each examination.

All examinations were carried out in the respective schools. The examiners were trained to collect the data in the best possible lighting, position and ergonomic conditions. The examinations took place with the child sitting on a chair, with his or her neck extended, and the examiner sitting opposite. While the examiner proceeded with the examination, a recorder completed the assessment form.

The first examination was performed using the ICDAS II caries codes: 0, sound; 1: first visual change in enamel, seen after drying; 2: distinct visual change in enamel; 3: localised enamel breakdown (without clinical visual signs of dentinal involvement); 4: underlying dark shadow from dentine; 5: distinct cavity with visible dentine; 6: extensive distinct cavity with visible dentine (over half of the tooth surface).

The second examination used WHO (1997) assessment criteria, which consider that caries is present when a lesion in a pit or fissure or on a smooth tooth surface has an unmistakable cavity, undermined enamel, or a detectably softened floor or wall. According to this criterion, the stages of caries that precede cavitation, as well as other conditions similar to the early stages of caries are excluded so they will be coded as sound. These conditions are: white or chalky spots, discoloured or rough spots that are not soft to touch with a metal CPI probe, stained pits or fissures in the enamel that do not have visual signs of undermined enamel or softening of the floor or walls, dark, shiny, hard, pitted areas of enamel in a tooth showing signs of moderate to severe fluorosis or lesions due to abrasions..

The study variables were the DMFT, DMFS, dft and dfs caries indices and the caries prevalence in permanent teeth (DMFT>0) and primary teeth (dft>0). The caries indicators for the 5-6 year-old group referred to primary teeth (dft, dfs and caries prevalence in temporary teeth) and those for the 12 and 15 year-old groups to permanent teeth (DMFT, DMFS and caries prevalence in permanent teeth).

These variables were obtained in accordance with the WHO caries diagnosis criteria and five cut-off points in the ICDAS II system. The ICDAS II cut-off points were established as follows: 1, ICDAS II code 0 was considered sound while codes 1-6 were classed as caries; 2, ICDAS II codes 0 and 1 considered sound and codes 2-6 classed as caries; and so on through to 5, ICDAS II codes 0-4 considered sound and codes 5-6 classed as caries.

Data analysis was carried out with the SPSS v18.0® program. The differences between the means of the DMFT/dft and DMFS/dfs indices were analysed with the Wilcoxon test and the McNemar test was used to study the difference between the proportions of caries prevalence. To assess agreement, the intraclass correlation index was used for the DMFT/dft and DMFS/dfs indices and the Kappa statistic for caries prevalence. The area under the ROC curve for caries prevalence according to the different cut-off points was also determined. In all the tests, values with $p < 0.05$ were considered statistically significant.

Results

Table 1 shows the caries index and prevalence results for the three age groups and a compares those of the WHO method with the five ICDAS II cut-off points. In 5-6 year-olds the least differences between the mean dft, mean dfs and caries prevalence figures according to the WHO method were found at cut-off point 2 in the ICDAS II system. Among the 12 year-olds, the least difference in mean DMFT was found at cut-off point 2 and that for DMFS at cut-off point 3. For caries prevalence, the WHO method results were the same as those for ICDAS II cut-off point 3. At age 15, significant differences in mean DMFT and DMFS were found at all the cut-off points ($p < 0.05$), but the least difference was observed at cut-off point 3. In this age group, cut-off point 2 was the only one that did not present a significant difference in caries prevalence ($p > 0.05$).

Table 2 shows the agreement between the WHO method and the four ICDAS cut-off points for the caries indices and prevalences of the three age groups. At 5-6 years the greatest agreement between the DMFT/dft assessed by the WHO method and by ICDAS II was at cut-off point 2, but at both 12 and 15 years it was found at cut-off point 3. For DMFS/dfs the greatest agreement was also observed at cut-off point 2 at age 5-6 and at cut-off point 3 at both 12 and 15 years. For prevalence, the greatest agreements were observed at cut-off point 3 for the 5-6 and 12 year-old groups but at cut-off point 2 for the 15 year-olds.

In Table 3, the diagnostic equivalence between the two methods given by the greatest area under the Receiver Operating Characteristic, ROC, curve (AUC) can be seen at ICDAS II cut-off point 3 (0.853, 0.861 and 0.850 respectively for the 5-6, 12 and 15 year-old groups).

Discussion

ICDAS was designed to expand the range of caries diagnosis possibilities by using visual criteria, correlated to histological criteria, which include precavitation lesions, making it possible to diagnose early lesions reliably and treat them non-invasively before they reach a stage of cavitation at which conventional filling is the only possible treatment.

The marked trend towards a decline in cavitated lesions and a parallel rise in precavitation lesions (Kuhnisch *et al*., 2008) means that lesions need to be diagnosed and we need to be aware of their presence, as they are increasing among the population. The presence of this type of lesion would seem to suggest the use of ICDAS II in epidemiology so that appropriate prevention and treatment strategies can be applied. According to Ismail (2004), ICDAS provides the diagnostic level required for public dental health planning.

In order to compare the results of studies conducted in accordance with the ICDAS II criteria with past WHO

Table 1. Comparison of DMFT/dft, DMFS/dfs and prevalence in the three age groups according to WHO criteria and different ICDAS II cut-off points

| | | WHO | ICDAS II cut-off point | | | | |
			Point 1 (ICDAS 1-6)	Point 2 (ICDAS 2-6)	Point 3 (ICDAS 3-6)	Point 4 (ICDAS 4-6)	Point 5 (ICDAS 5-6)
5-6 years (n=29)	dft[1] 95% CI Sig.	1.45 (0.76-2.13)	1.62 (0.94-2.31) 0.407	1.59* (0.91- 2.26) 0.420	0.72 (0.32-1.13) 0.002	0.66 (0.26-1.05) 0.001	0.41 (0.12-.71) 0.001
	dfs[1] 95% CI Sig.	1.55 (0.84-2.27)	1.86 (1.12-2.61) 0.207	1.83* (1.09-2.57) 0.216	0.89 (0.39-1.39) 0.005	0.83 (0.33-1.34) 0.003	0.58 (0.15-1.02) 0.003
	Prevalence[2] 95% CI Sig.	58.6% (40.7%-74.5%)	65.5% (47.3%-80.1%) 0.687	65.5%* (47.3%-80.1%) 0.687	41.4% (25.5%-59.6%) 0.063	37.9% (22.7%-56%) 0.031	27.6% (14.7%-45.7%) 0.004
12 years (n=32)	DMFT[1] 95% CI Sig.	2.22 (1.42-3.02)	2.94 (1.81-4.07) 0.046	2.06* (1.24-2.88) 0.825	1.88 (1.20-2.55) 0.162	1.28 (0.72-1.85) 0.004	1.09 (0.55-1.63) 0.003
	DMFS[1] 95% CI Sig.	2.72 (1.65-3.79)	3.5 (2.12-4.88) 0.142	3.5 (2.12-4.88) 0.142	2.31* (1.45-3.18) 0.181	1.56 (0.87-2.25) 0.009	1.38 (0.69-2.06) 0.007
	Prevalence[2] 95% CI Sig.	65.6% (48.3%-79.6%)	75.0% (57.9%-86.7%) 0.453	71.9% (54.6%-84.4%) 0.727	65.6%* (48.3%-79.6%) 1.00	50% (33.6%-66.4%) 0.180	43.8% (28.2%-60.6%) 0.065
15 years (n=40)	DMFT[1] 95% CI Sig.	2.4 (1.67-3.15)	4.7 (3.71-5.69) <0.001	3.73* (2.87-4.58) 0.002	1.43 (0.81-2.04) <0.001	0.93 (0.38-1.47) <0.001	0.78 (0.25-1.30) <0.001
	DMFS[1] 95% CI Sig.	2.83 (1.89-3.76)	5.33 (4.13-6.52) <0.001	5.00 (3.81-6.19) <0.001	1.63* (0.89-2.35) <0.001	1.10 (0.43-1.77) <0.001	0.90 (0.27-1.53) <0.001
	Prevalence[2] 95% CI Sig.	75% (59.8%-85.8%)	92.5% (80.1%-97.4%) 0.016	87.5% * (73.8%-95'4%) 0.063	52.5% (37.5%-67.1%) 0.004	35% (22.1%-50.5%) <0.001	27.5% (16.1%-42.8%) <0.001

[1]Wilcoxon test   [2]McNemar test   *Least statistical difference between means or proportions

Table 2. Agreement between indices and caries prevalence determined by WHO and ICDAS II criteria cut-off points

| | | DMFT/dft by ICDAS II criteria cut-off points (Intraclass correlation index) | | | | |
	Age in years	Point 1 (ICDAS 1-6)	Point 2 (ICDAS 2-6)	Point 3 (ICDAS 3-6)	Point 4 (ICDAS 4-6)	Point 5 (ICDAS 4-6)
DMFT/dft by WHO criteria	5-6, n=29	0.598	0.621*	0.567	0.544	0.363
	12, n=32	0.644	0.616	0.805*	0.620	0.503
	15, n=40	0.395	0.472	0.664*	0.488	0.567
		DMFS/dfs by ICDAS II criteria cut-off points (Intraclass correlation index)				
DMFS/dfs by WHO criteria	5-6, n=29	0.631	0.651*	0.628	0.608	0.464
	12, n=32	0.587	0.587	0.652*	0.481	0.396
	15, n=40	0.378	0.436	0.646*	0.499	0.568
		Prevalence by ICDAS II criteria cut-off points (Kappa statistic)				
Prevalence by WHO criteria	5-6, n=29	0.563	0.563	0.665*	0.603	0.424
	12, n=32	0.481	0.421	0.723*	0.438	0.338
	15, n=40	0.391	0.600*	0.538	0.304	0.224

*Highest value obtained or highest significant value

Table 3. Equivalence of caries diagnosis by WHO and ICDAS II criteria cut-off points

	Age in years	Prevalence by ICDAS II criteria cut-off points (Area under curve)				
		Point 1 (ICDAS 1-6)	Point 2 (ICDAS 2-6)	Point 3 (ICDAS 3-6)	Point 4 (ICDAS 4-6)	Point 5 (ICDAS 4-6)
Prevalence by WHO criteria	5-6, n=29	0.775	0.775	0.853*	0.824	0.735
	12, n=32	0.725	0.701	0.861*	0.742	0.695
	15, n=40	0.650	0.750	0.850*	0.733	0.683

*Highest value obtained or highest significant value

method epidemiological studies a point where the two are equivalent needs to be sought.

In our study we compared the total values of the DMFT/dmft and DMFS/dmfs indexes. The F component and the M component do not have any differences as they were recorded with the first code of the ICDAS II. The only difference was in the D component. On the other hand, we do not take into account the root caries, as it is a child population.

The limitations of the present study are possible examiner bias and the size of the sample. The first was controlled through calibration. Both the examiner obtained excellent calibration results. The possibility of across-criterion bias was avoided by using two different examiners, each calibrated for only one diagnostic method. The objection regarding sample size has been reduced by comparing the three age groups recommended by the WHO for epidemiological studies (5-6, 12 and 15 years old) independently, employing non-parametric comparison tests. In previously published studies on this subject (Braga *et al.,* 2009b; Mendes *et al.*, 2010), the children examined were under 5 years old rather than the ages recommended by the WHO.

The comparison of caries indices and prevalence in this study found equivalences at between ICDAS II cut-off points 2 and 3 for the three age groups studied. These results are similar to those published by Braga *el al*., (2009b) and Mendes *et al*., (2010) who placed the equivalence at ICDAS II cut-off point 3. Analysis of agreement did not show an exact cut-off point either, although most of the results showed point 3 to be suitable, with exceptions at point 2. A similar result was obtained when using ROC curves to study the best equivalent, which was again found to be cut-off point 3.

Studies of exfoliated primary teeth (Braga *et al*., 2009a, 2010) have shown that teeth classified as ICDAS II code 3 already present histological evidence of lesion in the dentine. As a result, they have concluded that at this stage the caries is already advanced and has penetrated beyond the enamel, although cavitation has not yet occurred, and that this could be considered caries according to the WHO criteria.

De Amorim *et al*. (2012) consider the results obtained with ICDAS II cannot be compared with those obtained with the WHO criteria. The ICDAS II and WHO caries assessment criteria are obviously not similar and although ICDAS II makes it possible to diagnose progressive stages of caries, finding an equivalent to the WHO caries criterion in the ICDAS II codes does not appear to be an easy task. According to Braga *et al*. (2009b), the results obtained with our study show that cut off point 3 could be the best approach for the comparison of the results obtained with

WHO criteria and ICDAS II criteria.

References

Agustsdottir, H., Gudmundsdottir, H., Eggertsson, H., Jonsson, S.H., Gudlaugsson, J.O., Saemundsson, S.R., Eliasson, S.T., Arnadottir, I.B. and Holbrook, W.P. (2010): Caries prevalence of permanent teeth: a national survey of children in Iceland using ICDAS. *Community Dentistry and Oral Epidemiology* **38**, 299-309.

Braga, M.M., Ekstrand, K.R., Martignon, S., Imparato, J.C., Ricketts, D.N. and Mendes, F.M. (2010): Clinical performance of two visual scoring systems in detecting and assessing activity status of occlusal caries in primary teeth. *Caries Research* **44**, 300-308.

Braga, M.M., Mendes, F.M., Martignon, S., Ricketts, D.N. and Ekstrand, K.R. (2009a): In vitro comparison of Nyvad's system and ICDAS-II with Lesion Activity Assessment for evaluation of severity and activity of occlusal caries lesions in primary teeth. *Caries Research* **43**, 405-412.

Braga, M.M., Oliveira, L.B., Bonini, G.A., Bonecker, M. and Mendes, F.M. (2009b): Feasibility of the International Caries Detection and Assessment System (ICDAS-II) in epidemiological surveys and comparability with standard World Health Organization criteria. *Caries Research* **43**, 245-249.

Cadavid, A.S., Lince, C.M. and Jaramillo, M.C. (2010): Dental caries in the primary dentition of a Colombian population according to the ICDAS criteria. *Brazilian Oral Research* **24**, 211-216.

de Amorim, R.G., Figueiredo, M.J., Leal, S.C., Mulder, J. and Frencken, J.E. (2012): Caries experience in a child population in a deprived area of Brazil, using ICDAS II. *Clinical Oral Investigations* **16**, 513-520.

International Caries Detection and Assessment System (ICDAS a) Coordinating Committee. www.icdas.org.

International Caries Detection and Assessment System (ICDAS b) Coordinating Committee. http://icdas.smile-on.com

Ismail, A. (2004): Diagnostic levels in Dental Public Health Planning. *Caries Research* **38,** 199-203.

Kuhnisch, J., Berger, S., Goddon, I., Senkel, H., Pitts, N. and Heinrich-Weltzien, R. (2008): Occlusal caries detection in permanent molars according to WHO basic methods, ICDAS II and laser fluorescence measurements. *Community Dentistry and Oral Epidemiology* **36**, 475-484.

Mendes, F.M., Braga, M.M., Oliveira, L.B., Antunes, J.L., Ardenghi, T.M. and Bonecker, M. (2010): Discriminant validity of the International Caries Detection and Assessment System (ICDAS) and comparability with World Health Organization criteria in a cross-sectional study. *Community Dentistry and Oral Epidemiology* **38**, 398-407.

Pine, C. and Harris, R. (2007): *Community Oral Health*. London: Quintessence.

Reisine, S., Tellez, M., Willem, J., Sohn, W. and Ismail, A. (2008): Relationship between caregiver's and child's caries prevalence among disadvantaged African Americans. *Community Dentistry and Oral Epidemiology* **36,** 191-200.

WHO (1997): *Oral Health Surveys. Basic Methods* 4th edn, pp 41-44. Geneva: WHO.