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Caries assessment spectrum treatment: the severity score

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Objectives: To appraise the feasibility of the caries assessment spectrum and treatment (CAST) severity score according to the formula (F) recommended in the CAST manual. **Methods:** Data from an epidemiological survey of 680 schoolchildren (mean age ± standard deviation: 7.45 ± 0.91 years), living in a low-income area in Brasília, were used. The CAST instrument was used for assessing enamel carious lesions (CAST code = 3), dentine carious lesions (CAST codes = 4–7) and tooth loss from caries (CAST code = 8). **Results:** The prevalence of carious lesions including enamel and dentine in both deciduous and permanent dentitions was 49.41% and 69.12%, respectively. Calculating the CAST severity score per child using F was unsatisfactory because of the undiscriminating weight given for each CAST code. Modification of weights according to the accepted levels of disease severity for individual CAST codes resulted in a new formula (F1), in which the weight given to cavitated dentine lesions was quadrupled in relation to that given to enamel carious lesions; this was different from F, in which the weight given to such lesions was twofold. F1 was able to categorise satisfactorily the study children into one of three levels of dental caries severity: mild (34.1%); moderate (29.5%); or severe (36.4%). **Conclusion:** According to the outcomes of the present appraisal, it was concluded that the numerical score provided by the CAST severity scores allows an overview of the severity of caries disease and the classification of individuals into mild, moderate or severe levels of dental caries when the new formula (F1) is used.

Key words: *Dental caries, epidemiological index, prevalence, caries assessment spectrum treatment, caries epidemiology*

INTRODUCTION

Most epidemiological surveys worldwide follow the detection criterion for carious lesions that is proposed by the World Health Organization (WHO)[1], which involves the identification of decayed (D), missing (M) and filled (F) (DMF) teeth. However, despite being advantageous in terms of simplicity, the WHO criterion has major disadvantages that make it out of touch with current concepts of prevention and treatment of dental caries[2,3]. In order to avoid using many different caries indices, the International Caries Detection and Assessment System (ICDAS) was proposed[4]. The aim of ICDAS is to enable a more detailed assessment of dental caries than obtained with indices previously used. Although the ICDAS system identifies three different stages of enamel carious lesions, it is not entirely discriminatory with regard to untreated carious lesions. Furthermore, certain difficulties have been reported regarding the system's application in epidemiological surveys[5–9].

In this context and considering the need for a system that encompasses the early, as well as the most advanced, stages of dental caries, a new caries-detection instrument, termed caries assessment spectrum and treatment (CAST), was proposed[10]. The instrument was validated for face, content and construct[11,12], and its reliability for use in epidemiological studies was reported[13–16].

The CAST instrument was derived from a combination of elements from the ICDAS and the WHO criterion, in addition to the exposed pulp and fistula/abscess scores originally proposed by Monse *et al.*[17]. It includes codes for the assessment of healthy teeth, enamel carious lesions, untreated dentine carious lesions, lesions with pulpal involvement and abscess/

fistula, and tooth loss. It follows a hierarchical order, with higher scores representing conditions of greater severity (*Table 1*). It is possible to convert the CAST codes into DMF components, which allows the comparison of results of recent studies with those of studies that have used the WHO criterion[2,3].

A manual containing a detailed description of the instrument and information regarding calibration and data presentation has been produced[18]. The manual also proposes the calculation of a CAST severity score, in which progressively higher codes are given progressively greater weight in the formula, with greater severity reflected by high codes (morbidity/mortality) and lesser severity reflected by low codes (healthy). However, the applicability of the CAST severity score has not been tested. Therefore, the present study aimed to demonstrate the applicability of the CAST severity score and, based on this score, to evaluate the possibility of stratifying a population as having mild, moderate and severe levels of disease.

Table 1 Codes and descriptions of the hierarchically ordered caries assessment spectrum treatment (CAST) epidemiological instrument, including disease status[11]

Characteristic	Disease status	Code	Description
Sound	Healthy	0	No visible evidence of a distinct carious lesion is present
Sealant	Healthy	1	Pits and/or fissures are at least partially covered with a sealant material
Restoration	Healthy	2	A cavity is restored with an (in)direct restorative material
Enamel	(Pre)morbidity	3	Distinct visual change in enamel only. A clear caries-related discoloration is visible, with or without localised enamel breakdown
Dentine	Morbidity	4	Internal caries-related discoloration in dentine. The discolored dentine is visible through enamel, which may or may not exhibit a visible localised breakdown of enamel
	Morbidity	5	Distinct cavitation into dentine. The pulp chamber is intact
Pulp	Severe morbidity	6	Involvement of pulp chamber. Distinct cavitation reaching the pulp chamber or only root fragments are present
Abscess/ fistula	Severe morbidity	7	A pus-containing swelling or a pus-releasing sinus tract related to a tooth with pulpal involvement
Lost	Mortality	8	The tooth has been removed because of dental caries
Other		9	Does not correspond to any of the other descriptions

MATERIALS AND METHODS

Ethical clearance

In order to test the efficacy of formula F in a population, we used the data from an epidemiological survey of 680 schoolchildren, between 6 and 8 years of age, from Estrutural, an urban, low-income area in Brazil's Federal District of Brasília[19]. The study was approved by the Research Ethics Committee of the Faculty of Health Sciences of the University of Brasília (CAAE 20976113.3.1001.0030) and authorised by the local education department. All children, 6–8 years of age, from the two public schools of this area were invited to participate in the epidemiological study (830 children in total). All children whose parents signed the informed consent form were included (680 children). The research was conducted in full accordance with the World Medical Association Declaration of Helsinki. Children in need of dental treatment were either treated at the school or referred to the Paediatric Dentistry Clinic of the University Hospital of Brasilia.

Calibration of examiners

Clinical examination was performed by two examiners who were trained and calibrated in the use of the CAST instrument. Training and calibration of the examiners were conducted in accordance with the instructions in the CAST manual[18]. Training included a 2-hour theoretical class provided by an experienced examiner and a practical session in which children of the same age group as those of the main study were assessed using the CAST instrument. The calibration was concluded after the examiners achieved adequate levels of intra- and inter-examiner agreement.

Dental examination and reliability of data collection

Clinical examination were performed at each of the schools in a room made available for the study and used a portable bed, help desk and artificial light. Before starting the clinical examination, examiners removed dental plaque using toothbrush, toothpaste and dental floss. Teeth were evaluated with the aid of cotton, gauze and the Community Periodontal Index (CPI) probe, according to WHO Oral Health Surveys Basic Methods[1]. Data were recorded by trained dental students. Intra- and inter-examiner agreement coefficients were calculated on the basis of 10% of the study population. The intra-examiner agreement coefficients for Examiners 1 and 2 were 0.79 and 0.82, respectively, while the inter-examiner agreement

coefficient was 0.90. According to Landis and Koch[20], these kappa coefficient values reflect a high level of agreement.

CAST severity score

As the CAST instrument is fairly detailed and uses a hierarchical structure (*Table 1*), a similar approach was used for formulating the CAST severity score[18]. According to the CAST manual, the severity score is obtained by first selecting the maximum CAST score per tooth (the highest code among the codes of all surfaces of an examined tooth). This information is then applied to formula F, as shown below:

$$F = \mathrm{CAST3} + 2 * \mathrm{CAST4} + 3 * \mathrm{CAST5} + 4 * \mathrm{CAST6} + 5 * \mathrm{CAST7} + 6 * \mathrm{CAST8}$$

The 'number*' denotes the weight given to the accompanying CAST code. The CAST codes 0, 1 and 2 are not part of this formula because they indicate healthy conditions (sound, sealed, and restored tooth or surfaces, respectively). The CAST codes 3–8 make up the formula and increasingly larger weights are assigned in accordance with higher codes. The largest weight is assigned to CAST 8, which indicates tooth loss (mortality). Consequently, the higher the final CAST severity score, the poorer the condition of the tooth or dentition.

RESULTS

Prevalence of dental caries

Of the children included in the epidemiological study, 337 (49.56%) were male and 343 (50.44%) were female. The mean age ± standard deviation was 7.45 ± 0.91 years. The distribution per school was as follows: 405 (59.56%) children in the first school and 275 (40.44%) children in the second school. The prevalence of dental caries was calculated using the subject CAST score. Considering CAST codes 5–7, the prevalence of dental caries in both deciduous and permanent teeth was 49.41%. Including enamel carious lesions and non-cavitated dentine carious lesions (codes 3 and 4), the prevalence of dental caries was 69.12%.

In order to determine the maximum CAST score per subject, the prevalence of dental caries in deciduous and permanent dentition was calculated separately. The prevalence of dental caries in the deciduous dentition considering only cavitated dentine carious lesions was 47.79%, while that considering enamel, cavitated and non-cavitated dentine carious lesions was 65.44%. These values were calculated on the basis of the data from all 680 children because all of them had deciduous teeth.

The prevalence of dental caries in the permanent dentition considering only cavitated dentine carious lesions was 8.81%. Including enamel and non-cavitated dentine carious lesions, the prevalence of dental caries was 38.18%. These values were calculated using data from 647 children.

Application of formula F

Using the data collected from the clinical examination of 680 children, it was possible to apply formula F and calculate the CAST severity score for each subject. The mean ± standard deviation of the severity score using formula F was 10.4 ±10.7, while the median (interquartile range) was 7 (2–16). As the severity scores were not normally distributed, the median, along with the interquartile range (25–75%), was used as the measure of central tendency, as presented in *Figure 1*. On the basis of the results of the descriptive analysis, we chose to stratify the population into three levels, according to disease severity: mild (0–25%); moderate (25–75%); and severe (>75%). After applying formula F, 28.7% of the children were classified as having a mild level of disease (CAST severity score of 0–2), 46.9% as having a moderate level of disease (CAST severity score of 2–16) and 24.4% as having a severe level of disease (CAST severity score of >16).

Table 2 presents data from a selected number of children with different distribution of teeth per CAST code but similar CAST severity scores or stratification levels (mild, moderate or severe) according to formula F. Using formula F, we observed that children with a predominance of enamel carious lesions were categorised as having moderate or even severe levels of disease (patients 5, 6, 7 and 8 in *Table 2*). On the other hand, there were patients (1, 2, 3 and 4) for whom the presence of advanced lesions in dentine, even with pulp involvement, was insufficient to classify them as having a moderate or severe level of dental caries. These extremes showed that formula F may not be the correct formula for classifying children according to level of disease severity. The reason may be the linear increase in weight given to the codes, whereas the severity of caries conditions did not increase linearly. For this reason, we modified the formula by changing the weights and the way of stratifying the population, resulting in formula F1.

Development of formula F1

We reduced the weight given to enamel carious lesions (premorbidity) from 1 (F) to 0.25 (F1) and the

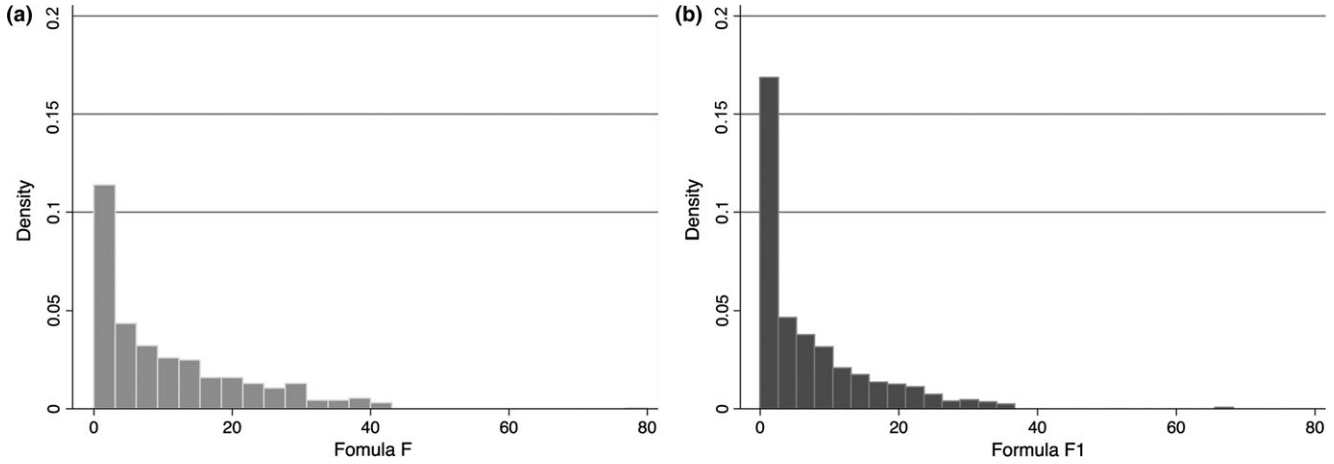

Figure 1. Histogram distribution of the severity score according to formulae F (a) and F1 (b).

Table 2 Caries assessment spectrum and treatment (CAST) severity scores and severity-based classification of a group of individuals according to the original formula (F), considering the maximum CAST score per tooth

Patient no.	CAST code						CAST severity score	
	3	4	5	6	7	8	F	F
1	2	0	0	2	0	0	10	Moderate
2	0	3	1	0	1	0	14	Moderate
3	2	0	3	1	0	0	15	Moderate
4	4	0	2	0	1	0	15	Moderate
5	5	0	0	0	0	0	5	Moderate
6	4	0	0	0	0	0	4	Moderate
7	1	1	0	0	0	0	3	Moderate
8	11	0	2	0	0	0	17	Severe
9	2	1	8	0	0	0	28	Severe
10	1	0	3	2	2	0	28	Severe

Values given in the table represent the number of teeth per CAST code.

weight given to the less severe carious lesions in dentine (morbidity) from 2 (F) to 1 (F1) and from 3 (F) to 2 (F1). For the codes given to the carious lesions of highest severity (CAST codes 6–8), the weight was maintained, as shown in formula F1, as follows:

$$F1 = 0.25 * \text{CAST3} + 1 * \text{CAST4} + 2 * \text{CAST5} + 4 * \text{CAST6} + 5 * \text{CAST7} + 6 * \text{CAST8}$$

The 'number*' denotes the weight given to the accompanying CAST code. After using formula F1, the CAST severity score still showed a skewed distribution (*Figure 1*). The mean ± standard deviation of the severity score using formula F1 was 6.9 ± 8.4, while the median (interquartile range) was 4 (0.5–10.5). For the categorisation of children, a new division was proposed by grouping the population into thirds. Following this division (33–66%), 34.1% of children were categorised as having a mild disease level (CAST severity score of 0–1.25), 29.5% as having a moderate disease level (CAST severity score of 1.25–6.75) and 36.4% as having a severe disease level (CAST severity score of >6.75).

With data from the study population, 236 children presented only enamel carious lesions, which varied from 1 to 11 lesions per child. Using formula F and the interquartile division, 47 children were classified into the moderate disease group and 189 into the mild disease group. Using formula F1 and the tertile division, 33 of the 47 children were reclassified as having a mild level of the disease and 14 maintained their moderate level of the disease classification owing to their high number of enamel carious lesions (six or more). Regarding lesions with a CAST code of 6, 136 children presented at least one tooth with this code. Using formula F, 37 of those children were classified as having a moderate level of the disease and 98 a severe level. After applying formula F1, 26 of the 37 children were reclassified into the severe disease group. The same direction of change was observed for lesions with a CAST code of 7. Using the quartile division, formula F placed 16 of the 52 children with at least one tooth scored with a CAST code of 7 in the moderate group. Formula F1 left only one child in the moderate group and reclassified 15 children as being in the severe group. *Table 3* presents the severity scores and severity-based classification of a group of subjects according to formulae F and F1, exemplifying the important changes that formula F1 brought to the classification.

DISCUSSION

The present study, which appraises the feasibility of using CAST severity scores in a population of children

Table 3 Caries assessment spectrum and treatment (CAST) severity scores and severity-based classification of a group of subjects according to the formulae F and F1, considering the maximum CAST score per tooth

Patient no.	CAST code						CAST severity score			
	3	4	5	6	7	8	F	F1	F	F1
1	11	0	2	0	0	0	17	6.75	Severe	Moderate
2	5	0	0	0	0	0	5	1.25	Moderate	Low
4	1	0	2	1	0	0	11	8.25	Moderate	Severe
5	4	0	4	0	0	0	16	9.0	Moderate	Severe
6	1	0	2	0	1	0	12	9.25	Moderate	Severe
7	0	1	0	0	0	0	2	1.0	Low	Low
8	0	0	2	0	0	0	6	4.0	Moderate	Moderate
9	0	0	0	0	1	1	11	11.0	Moderate	Severe
10	1	2	0	1	0	0	9	6.25	Moderate	Moderate
11	0	1	0	0	1	0	7	6.0	Moderate	Moderate

Values given in the table represent the number of teeth per CAST code.

with a high prevalence of dental caries, is a pioneer in the use of CAST severity scores. Overall, the outcomes indicate that the CAST severity scores and stratification of the population into different levels of disease severity were not only effective as tools for use in epidemiological surveys but also provided additional information regarding the extent to which dental caries had affected the study population. This finding was attained after modifying the original formula for calculating the CAST severity scores and classifying the population by using the severity score distribution divided into tertiles, according to the level of disease severity (i.e. mild, moderate and severe).

In order to rectify the inefficacy of the original formula, we modified the weights assigned to the CAST codes. The weight of the enamel carious lesion (CAST 3) in formula F was reduced four-fold. This decision was taken mainly for two reasons. First, the CAST instrument does not discriminate active from arrested carious lesions and, second, studies have shown that enamel carious lesions, even if active, exhibit a slower rate of progression than do dentine carious lesions[21]. By reducing the weight originally assigned to CAST 3, children with a significant number of enamel carious lesions, who, according to formula F, were categorised as having a severe level of disease, were reassigned to the group with moderate level of disease (*Table 3*; Patient 1). This was achieved by using tertiles, and not interquartile range, to distribute the severity scores.

On the basis of the modification of the weight assigned to enamel carious lesions, the modification of the weights assigned to the other components of formula F1 was performed as follows: CAST 4 dentine carious lesions were considered four times more severe than enamel carious lesions and two times less severe than cavitated dentine carious lesions (CAST 5) and were assigned a weight of 1. The same logic was applied to cavitated lesions (CAST 5; assigned a weight of 2) as well as to lesions with pulp involvement (CAST 6; assigned a weight of 4). In other words, CAST 6 was considered as two times more severe than CAST 5. Pulp involvement is usually accompanied by episodes of pain, which negatively affect the quality of life of the individual[22] and render the tooth more vulnerable to mortality. Therefore, dentine cavities with pulp involvement are more severely affected than are cavities in dentine without pulp involvement. The CAST 7 code describes the presence of an abscess or fistula (severe morbidity stage) and was assigned a weight of 5 because it represents an escalation of the situation described under CAST 6. The CAST 8 code indicates the inability to reverse the previous stages of disease because it records tooth loss from dental caries (mortality). Therefore, it was assigned the highest weight of 6. These modifications of the original formula F, resulting in formula F1, ensured better discrimination of individuals according to disease severity when the tertile distribution was used.

The appraisal of the CAST severity score enables quantification of disease severity. In this context, the CAST severity score bears similarity to the globally used DMF index proposed many years ago by Klein *et al.*[23] However, unlike the DMF index, which is always cumulative, CAST severity scores can decrease and increase depending on whether or not treatment is performed. A restored dentine cavity is considered healthy and is therefore not included in the severity score calculation. Thus, we have the example of patient 5 (*Table 3*), in which the child was classified as having a severe level of dental caries as they presented four teeth with cavities into dentine, which resulted in a CAST severity score of 9. After these lesions had been treated, the child would be assigned to the mild disease-severity group as the CAST severity score would have become 1, based on the four enamel carious lesions that were still present. Patient 11 (*Table 3*) shows a different picture. This child was classified as belonging to the moderate disease-severity group as they presented a tooth with a non-cavitated dentine carious lesion and another tooth with a fistula/abscess (CAST severity score = 6). If no curative treatment took place, the likelihood that the non-cavitated carious lesion would progress into an obvious dentine carious lesion would be high. It is very likely that the tooth with a fistula would be extracted. In a follow-up examination, the child would be assigned to the severe disease-severity group (CAST severity score = 10).

It is believed that achieving final numerical values of disease severity not only facilitates dialogue

between epidemiologists from different parts of the world but also enables the comparison of data from various epidemiological surveys. In addition, the score allows a better surveillance of public health data regarding the treatments performed in a certain population in order to verify if the extension/severity of the disease has been reduced and the disease is under control. Although CAST severity scoring has potential for global application, the division of children into one of the three categories is limited by the prevalence and extent of the caries situation in the (child) population under study. It is probable that a child who is considered as having a severe level of disease in one population would be considered to have a moderate or even mild level of disease severity if it belonged to another population. As the prevalence of dental caries in the child population in the present study was high, the CAST maximum severity score reached 40. The maximum score would only be 20 if the prevalence of dental caries in a child population was lower.

This is the first time that the CAST severity scoring system has been tested in an epidemiological study, which is a limitation. This limitation makes it necessary to test the scoring system using formula F1 in populations with a wide range of age groups and with different rates of prevalence of dental caries. The application of the CAST severity scores in other epidemiological surveys will help epidemiologists to arrive at an overall classification of individuals into an agreed consensus of the minimum and maximum score for each of the three categories: mild; medium; and severe. Further studies that test the applicability of the CAST severity score in other population groups of different dental caries prevalence and ages are required.

In conclusion, the use of CAST severity scores provides a numerical system that allows an overview of the severity of caries disease and also the classification of individuals into mild, moderate or severe levels of dental caries. Modifying the weights assigned to each of the CAST codes (maximum per tooth) in the original formula F resulted in a realistic formula F1, which allowed satisfactory categorisation of the study children into three groups based on the severity of dental caries.

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Conflict of interest

None declared.

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