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Caries Assessment Spectrum and Treatment (CAST): A Novel Epidemiological Instrument

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Abstract
Caries detection is fundamental to understanding the oral health status of a population and is the basis for caries diagnosis for individual patients. Although different caries detection/diagnosis criteria are available, none of them include the total spectrum of dental caries (which ranges from a sound tooth to a tooth lost due to caries) other than the Caries Assessment Spectrum and Treatment (CAST) instrument. The CAST codes and descriptions were submitted to experienced epidemiologists from across the world for obtaining face and content validity. Its construct validity and reproducibility under field conditions were tested in child and adult populations, and showed a high level of agreement between examiners. Compared to what is usually reported in the literature, CAST provides more relevant information on caries prevalence, experience, and severity. CAST is straightforward and easy to use. A manual with valuable information about how to apply CAST and report its results has been published in order to facilitate communication among researchers, oral health planners, and medical professionals. Feedback from researchers indicates that CAST is considered an asset and that reporting results after using CAST is uncomplicated. More research about the effects of CAST in different cultures and age groups is required.

Detecting carious lesions is as important as it is challenging for the dental professional. Government intervention programmes aimed at providing oral care to the public should ideally be planned and their impact measured on the basis of caries detection. This makes it essential for the detection instrument selected to be validated and easy to use to allow comparison of results between surveys conducted in different populations or over time in the same population, regardless of how dental services are organised.

In order to facilitate these comparisons, the World Health Organization (WHO) recommends the use of standardised methods for carrying out oral health surveys, including the collection of data according to the Decayed, Missing, and Filled Teeth (DMFT) index [World Health Organization, 2013]. Although the index has been proven to be easy to apply and to reach high levels of reproducibility even for population-based surveys [Wang et al., 2002], it has been criticised widely for not registering the initial stages of dental caries [Ismail, 1997; Casamassimo et al., 2009].

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Not only does the decrease in dental caries prevalence and experience reported for many countries justify changing the carious lesion detection threshold from dentine to enamel lesions, but the knowledge that the dental community has acquired in the last decades about controlling the disease initiation and progression also supports such a change. It is known that early carious lesions can be controlled through preventive measures in a way that makes such lesions very unlikely to progress to severer stages [Marinho, 2009].

There are still many communities in which the prevalence of cavitated dentine carious lesions is high, as shown by a systematic review that reports that 2.4 billion people worldwide are living with an open cavity in the permanent dentition and 61 million children show the same manifestation in the deciduous dentition [Kassebaum et al., 2015]. However, the systematic review does not provide information with respect to how many of these cavities have already reached the pulp and have developed an abscess. Obtaining this information is of great relevance as, without treatment, the chance that a person with pulp-involved and abscessed teeth experiences (continuous) pain is high [Figueiredo et al., 2011; Boeira et al., 2012].

The Caries Assessment Spectrum and Treatment (CAST) instrument emerged in response to the need for a more comprehensive carious lesion detection instrument as expressed above. CAST is an instrument that was developed and tested for use in epidemiological surveys and that covers the whole spectrum of carious lesion detection, from sound tooth surfaces to teeth with an abscess or fistula. The instrument has been validated for face, content, and construct [de Souza et al., 2012, 2014c]. Its reproducibility in clinical studies has been tested in child and adult populations [de Souza et al., 2014a]. CAST is considered a reliable instrument to be used in epidemiological surveys [de Souza et al., 2014a; Baginska et al., 2016]. A manual with directions on how to apply and report the results has been published [Frencken et al., 2015]. Moreover, the data obtained through the use of CAST can be converted to calculate a DMFT score [de Souza et al., 2014b]. The conversion allows the comparison of results of epidemiological surveys obtained through using CAST with results collected in the past according to, for example, the WHO caries assessment criterion.

The aim of this paper is to present the content and discuss the advantages and limitations of the CAST instrument and the possibilities it offers for reporting results of epidemiological surveys in a meaningful manner.

The Importance of Epidemiological Surveys for Oral Health Care

Epidemiological surveys are essential for planning and monitoring treatment programmes for specific health conditions. In the case of dental caries, they identify actions that need to be taken by considering the needs of a particular population. According to WHO policies, disease control programmes should focus on priority diseases (such as dental caries) in specific population groups [World Health Organization, 2008]. In terms of oral health, Brazil's last national survey conducted in 2010 is a good example of how important epidemiological surveys are in identifying existing problems and, consequently, implementing actions aimed at mitigating those problems. When analysing the survey data from children aged 12, it was observed that those living in the north region of the country presented a much higher mean DMFT score (3.16) in comparison to those living in the south-east (1.72). Worse than that, the D component indicated that 45.3% of the dentine cavities had been left untreated in children in the south-east, while the percentage of children in the north with this condition was 67.4% [Brazilian Ministry of Health, 2011]. These data clearly indicate that immediate action is required to reduce inequalities in access to oral health care between the 2 regions. But the results provide no information about the proportion of teeth that can be restored or that are already in need of endodontic treatment or extraction. This means that the caries detection system used was not able to portray the severity of the disease.

However, the level of detail needed to be gathered from an epidemiological survey is debatable. According to the WHO guidelines [World Health Organization, 2013], it is most important for public health to obtain information about the prevalence and incidence of dental caries. But, for planning purposes, information about the severity of dental caries is also important, as the example of Brazil highlights. This implies that a more detailed caries detection instrument that assesses not only dentine cavities but also whether the cavity can be restored or has pulp involvement or whether an abscess or fistula has developed is useful.

CAST Instrument: Rationale and Description of Codes

A 2004 review of caries detection systems included 29 criteria and revealed that these systems differed considerably in aspects such as definition of dental caries, content

Table 1. CAST codes and description

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

and examining conditions [Ismail, 2004]. Taking into account that these instruments are meant to be used internationally, they should be constructed to be simple and easy to use and should obtain similar results when compared to a gold standard test [Petrie et al., 2002]. Moreover, the assessment instrument should fulfil some clinical prerequisites such as: manageability (be cheap, fast, acceptable, and easy to learn), reproducibility (ability to show the same results when a sample is measured more than once by the same observer), and validity (able to detect and determine whether a disease is truly present) [Sturmans, 1986].

The CAST instrument was developed and tested following these principles [de Souza et al., 2012, 2014a, c]. CAST follows a hierarchical order in which a less severe condition precedes a severer one (Table 1). The advantage of the hierarchical order is that it facilitates an understanding of the disease severity: the higher the CAST code, the worse the condition.

CAST can be applied in dental clinics and in field conditions. In the latter case, it is advisable to use a portable light source. The instruments required for using CAST are a plain mouth mirror, CPI probe, gauzes, and cotton rolls. The air syringe is not recommended, and examinations should be performed on cleaned teeth (after toothbrush and dentifrice use).

CAST Instrument: How to Report the Data

To exemplify how data obtained through the use of CAST are reported, data collected from an epidemiological survey on 1,024 children aged 6–8 years (mean age 7.28 ± 0.6), carried out in a suburban area of Brasília, Brazil's Federal District, are discussed here.

The first important piece of information that an epidemiological survey about dental caries should provide concerns the prevalence of the disease. "Prevalence" refers to the proportion of a population that is diseased at a particular time [Coogan et al., 2003]. With respect to dental caries, people who are considered as diseased are those who have at least 1 tooth with a carious lesion at the time that the examination is being conducted. Since the development of the DMF index [Klein and Palmer, 1937], a tooth with a dentine cavitated carious lesion has been considered a diseased tooth. By changing the threshold to enamel carious lesions, such lesions are included in the calculation of caries prevalence, which also provides information about the percentage of individuals that present the disease in a premorbidity stage. However, for the last century, the prevalence of dental caries has been calculated on the basis of the DMFT index. This implies that the prevalence no longer refers to the disease only (D component) but refers also to treatment (M/F components). This century-old definition violates the epidemiological definition of prevalence of a disease.

Calculating the prevalence of dental caries according to CAST considers diseased subjects only. Those with teeth that have been treated either through a restoration (F component) or through extraction (M component) are excluded from the calculation of the prevalence of dental caries. These teeth are considered sound as the dentine cavity has been treated (F component) or because they do not represent a source of concern, as they have been extracted. A differentiation between the prevalence of den-

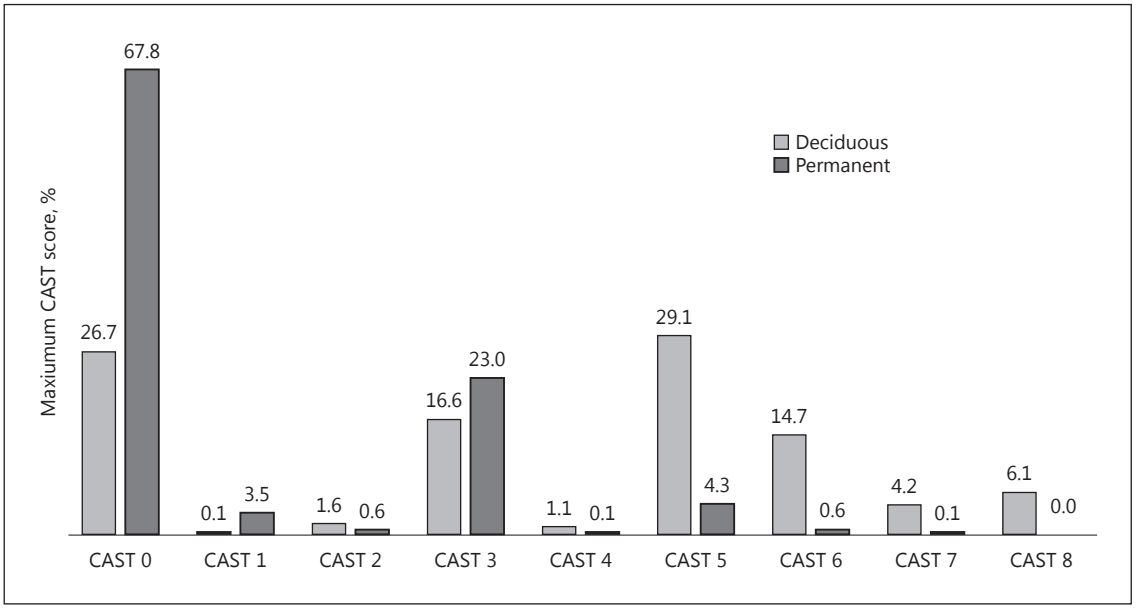

Fig. 1. Maximum CAST score per subject (percentage) by type of dentition.

tine carious lesions (CAST codes 4–7) and enamel and dentine carious lesions (CAST codes 3–7) can be made. Using the survey example above, the dental caries prevalence for the primary dentition of the schoolchildren was 68.6% (enamel and dentine carious lesions) and 52.0% (only dentine carious lesions), and 28.2 and 5.1% for the permanent dentition, respectively.

A DMF count can be constructed from CAST codes. The D component refers to CAST codes 5–7, the M component to CAST code 8, and the F component to CAST code 2. Using the CAST codes for determining the DMFT count, the prevalence of caries for the deciduous dentition would be 55.6 and 5.7% for the permanent dentition.

It is important to highlight that, for calculating caries prevalence, it is necessary to calculate first a maximum score per tooth and then a maximum score per subject. These scores are very informative as is shown in Figure 1, which indicates that only about 27% of the children were free of a carious lesion (maximum CAST score 0) in the primary dentition. In a population like the one used in the example, which consists of a mixed dentition, calculating the maximum CAST score per subject by dentition assists the reader in identifying disease stages in the permanent and in the deciduous teeth separately. Such a differentiation is helpful in planning oral health care strategies. It indicates that if no preventive action is taken, most probably these enamel carious lesions will progress to cavitation. But more than that, the high prevalence of children with a maximum CAST score of 5–7 indicates that these children are also in need of invasive care of a different nature.

The maximum CAST score per subject allows individuals to be grouped according to the severity of the disease. For this purpose, subjects with a maximum score of 0, 1, and 2 are classified as healthy; those presenting a maximum CAST score of 3 are judged to be in a premorbidity stage, and individuals with a maximum CAST score of 4 and 5 are in the morbidity stage. The classification severe morbidity contains subjects with a maximum CAST score of 6 or 7, and mortality is characterised by subjects with a maximum CAST score of 8. Figure 2 shows how the schoolchildren were distributed in accordance with this classification. There is no doubt that this is a diseased population as the majority of the subjects (50.0%) presented with at least 1 tooth in the morbidity or severe morbidity stages.

In cases where the disease is addressed through public health programmes and children receive adequate dental treatment, CAST allows the visualisation of the change in the disease situation, which is of great importance for understanding the transition pattern of oral health over time. Children that initially were grouped according to a maximum CAST score of 5, after treatment presented a maximum CAST score of 2, as all the

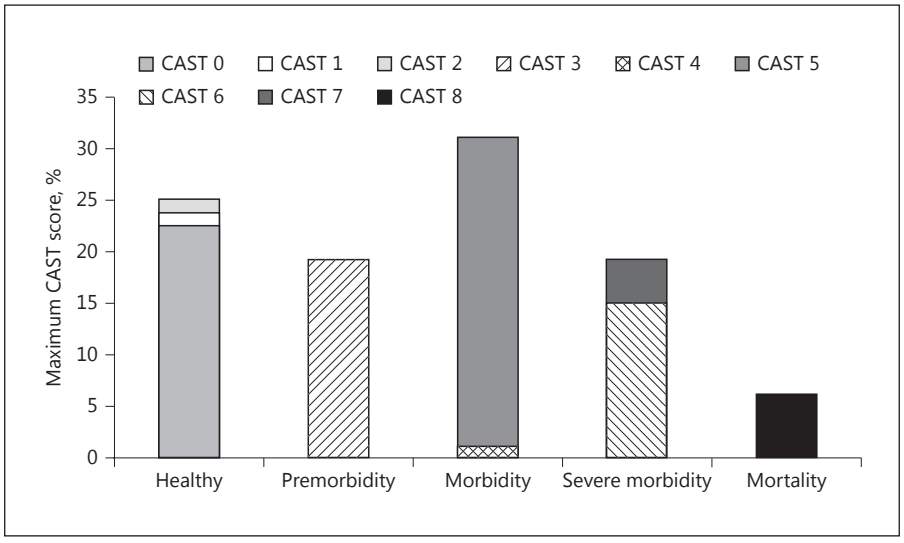

Fig. 2. Severity of the disease based on the maximum CAST score per subject (percentage).

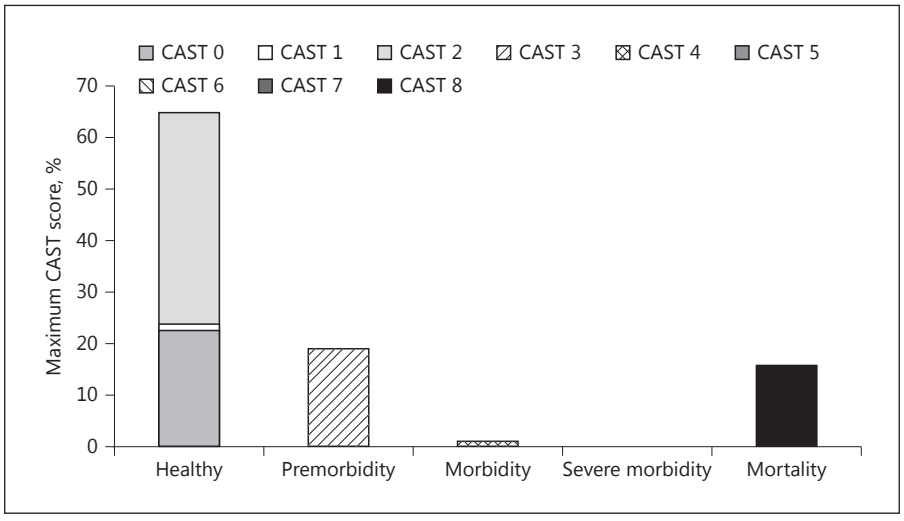

Fig. 3. Severity of the disease based on the maximum CAST score per subject – hypothetical scenario (percentage).

dentine cavities had been restored. For maximum CAST scores 6 and 7, we can hypothesise that half of the children had a root canal treatment performed and the other half had their teeth extracted. Considering this hypothetical scenario, Figure 3 shows how this population would be distributed according to the disease severity. Considering this change, less than 1% of the children would be in the morbidity stage (maximum CAST scores 4 and 5) and none would be in the severe morbidity stage (maximum CAST scores 6 and 7). The percentage of maximum CAST score 2 would change from 1.5 to 41.0%, increasing the number of subjects included in the healthy stage. As some teeth were treated through extraction, there would also be an increase in the number of subjects in the mortality stage.

This way of collecting and reporting data permits the assessment of whether an oral health programme implemented was effective, when the same population is compared over time. Such a detailed comparison of changes in oral health is not possible with any other caries detection or assessment index/system currently in use.

Final Remarks

The suitability of the CAST instrument for use in oral health is still being established. CAST has been tested and found valid for use in epidemiological studies only. It has not been tested for use in clinical practice and for under-

graduate training purposes, which is a limitation of the instrument.

As disease assessment instruments/indices for use internationally need to have a broad basis, obtaining face and content validity is of paramount importance. CAST codes and their descriptions underwent a thorough review by 56 epidemiologists from 15 countries on 5 continents [de Souza et al., 2012]. The large number and spread of epidemiologists over many countries and continents allowed the code descriptions as perceived by different cultures and social backgrounds to be debated [de Souza et al., 2012]. This is of great importance for an instrument that is developed to be used globally. During this process, changes were proposed and eventually accepted following consensus among all participating epidemiologists using the RAND modified e-Delphi method [Chang et al., 2010].

Epidemiological surveys in which the CAST instrument was used showed that it provided more information on the disease prevalence, experience, and severity than the DMF index [Baginska et al., 2014a] and that it is a useful tool for collecting epidemiological data regarding primary molars [Baginska et al., 2014b, 2016]. According to Malik et al. [2014], in using CAST it is possible to score the whole spectrum of dental caries more precisely.

Designed to be an epidemiological tool, the CAST instrument was developed not only for reporting dental caries prevalence and incidence but also for carrying out surveillance of oral health implementation programmes. According to the WHO, surveillance is defined as the systematic collection, analysis, and interpretation of specific data that will be important for planning, implementing and assessing public health policies and practices [World Health Organization, 2006]. People involved in these activities are usually policy makers at national, regional, and district levels. They need to have in hands data that are meaningful, straightforward, and easy to read, as provided by CAST.

On the basis of what has been presented in the present paper, it is concluded that CAST is a caries detection instrument that can be used worldwide in epidemiological surveys. Using its applicability in private practice needs to be researched. This instrument, the total spectrum of dental caries is assessed. CAST has been validated and its reproducibility is high. Moreover, CAST is easy to apply and reporting results is conducted in an easy and understandable fashion. Going forward, more research into the acceptability of CAST in different cultures and age groups is needed.

Disclosure Statement

The authors declare no conflict of interest.

Author Contributions

All authors participated in designing and writing the paper.

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