

Variations in caries diagnoses and treatment recommendations and their impacts on the costs of oral health care

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Objective: To evaluate the reproducibility of caries detection and treatment planning among public health dentists and estimate the possible impact of their decisions on financial costs. **Research design and settings:** Thirty nine dentists working in the public health service of Piracicaba, São Paulo, Brazil made a combined visual–radiographic caries examination of 40 occlusal surfaces of extracted permanent teeth mounted on two dental mannequins and proposed treatment plans for each tooth. Histological validation then evaluated the diagnoses validity and the suitability of the treatment plans. **Outcome measures:** Inter-examiner agreement was calculated by Cohen’s Kappa statistics. The sensitivity and specificity of caries detection and treatment decision were calculated. The costs of dental treatment plans for public health system were calculated from a Brazilian public health service fee scale. **Results:** Inter-examiner agreement for caries detection was moderate ($\kappa=0.42$) while for treatment decisions it was fair ($\kappa=0.29$). The sensitivity and specificity were 0.69 and 0.65 for caries detection and 0.56 and 0.65 for treatment decision respectively. Dentists overestimated the presence and depth of carious lesions and there was a tendency to treat enamel lesions using invasive therapeutic procedures. Mean treatment cost across the two cases was 32US\$ (range 9–65) while the histologically validated cost was 23US\$. **Conclusion:** The variability in caries detection and treatment decision negatively affected the cost of the dental treatment.

Key words: oral diagnosis, inter-examiner variability, health care costs, economics, public health system

Introduction

The new epidemiological pattern of dental caries is characterized by its low prevalence and the slow progression of carious lesions changing the lesion behaviour and the distribution of affected sites. Currently, at the macroscopic level, changes have been observed in lesion morphology, with dentinal caries developing slowly under a clinically intact enamel surface. This makes caries diagnosis more difficult, particularly in occlusal surfaces, in which a fissure system can mask a non-cavitated caries lesion spreading into dentine (Anusavice, 2003; Bönecker and Cleaton-Jones, 2003; Hopcraft and Morgan, 2006; Pitts, 2009). Further, it has implications for the quality of caries detection and treatment planning, resulting in inter-examiner divergences when making decisions about these procedures. (Bader and Shugars, 1995; Gray and Paterson, 1997; Espelid and Tveit, 2001; Anusavice, 2003; Mialhe *et al.*, 2009).

Public health services under heavy demand for oral health services risk dentists becoming mere reproducers of technical procedures, resulting in an imbalance between preventive and curative treatments. This situation may expose the population to overtreatment, adversely affecting their oral health status, as well as overburdening costs to the service (Mialhe *et al.*, 2009; Norlund *et al.*, 2009; Tubert-Jeanin *et al.*, 2004).

Although the literature presents studies evaluating inter-examiner variability with regard to caries diagno-

sis and treatment decisions, too little is known about this problem among dentists working in public health services (Gray and Paterson 1997; Mialhe *et al.*, 2007). In addition, the possible economic impacts of diagnosis and treatment decisions on the public health system have received little attention (Norlund *et al.*, 2009).

Therefore, the aim of the present study was to evaluate the inter-examiner variability with regard to the caries detection process and clinical decision making in a sample of dentists from a public health service and the possible impact of their decisions on costs for the health system and on the oral health of the population.

Method

All 39 general dental practitioners from the public dental services in Piracicaba, São Paulo, Brazil, corresponding to 61% of the dentists working in the local public health service, were invited to take part in the study. The other 39% worked in service specialities. Data were collected after approval by the Committee of Ethics in Research of the Piracicaba Dental School State University of Campinas, Protocol n° 24/2000, and obtaining the written informed consents of each participant.

Selected for the study were 40 permanent teeth (16 premolar and 24 molars), without evident cavitated carious lesions, dental restorations, signs of fluorosis or hypoplasia, extracted for orthodontic, periodontal or prosthodontic reasons. The teeth were mounted in two

dental mannequins, half of each type in each mannequin and kept in a thymol solution when not being examined.

The posterior regions of each mannequin were radiographed using standard intraoral films (Kodak Ektaspeed Plus) and exposures were made with a Dabi Atlante 70X dental radiograph machine operated at 70kVp, 8mA and 0.4s with 25-cm film-focus distance. After automatic processing, the radiographs were mounted in two radiographic charts for examination using a viewing box.

The models, radiographs and a portable viewing box were taken to the public health offices where the dentists work. During the examination, the mannequins were placed on the dental office chairs, simulating the position of a patient, following a previously described method (Bader *et al.*, 1994; Mialhe *et al.*, 2007; 2009).

The dentists were asked to examine the occlusal surfaces by visual-radiographic examination for detecting carious lesions and to make treatment decisions assuming that the teeth were from two 20 year-old adults, with good oral hygiene, who were visiting for a routine dental visit. The dentists could use an operating light, air syringe, radiograph viewer and dental mirror, but not dental explorers as changes in tooth surfaces might influence further examinations.

Treatment decisions were either “non-invasive” including “no care”, “sealants application”, “fluoridated varnish application”, “follow-up” and “topical fluoride application”; or “invasive” including “amalgam restoration”, “resin restoration”, “glass ionomer cement”, “preventive restoration”.

For histological validation each tooth was vertically sectioned at about 0.7-mm-thick intervals, in a buccolingual direction, using a band saw (Extec Corp, Enfield, CT USA) then analysed by two observers using a stereomicroscope at 4x magnification, on both sides, under light, using the score system criteria used by Ricketts *et al.* (1995). The ideal treatment, according to histological examination, for sound teeth would be “follow-up”; for teeth with carious lesions in enamel, “sealant application”; and “restorative treatment” when teeth presented carious lesions in dentine (Bader and Shugars, 2006).

The costs of dental treatment attributable to each dentist’s decision making were calculated by summing the recommended treatment cost using the Ambulatory Information System (SIA/SUS) fee scale adopted by the Brazilian public health service (Ministério da Saúde, 2006).

The inter-examiner agreement for caries detection and treatment decision was evaluated by Cohen’s weighted Kappa because the clinical conditions and treatment decisions were graded according to a simplified and rising scale of severity. For clinical condition the scale was coded: 0, no caries; 1, enamel caries; and 2, dentine caries. For treatment decisions the codes were: 0, none; 1, non-invasive; and 2, invasive. The 39 examiners were arranged in pairs for the inter-examiner agreement calculation. Finally, an average value of Kappa statistic for all pairs of examiners was taken. Frequency analysis was performed to assess the response distribution of decision-making performed by the dentists. The validity of caries detection and treatment decision was evaluated by sensitivity and specificity tests. The intra-examiner agreement was not analysed in this study.

Results

The histological examination of the 40 teeth demonstrated that 22 (55%) were sound, 8 (20%) had enamel caries and 10 (25%) had dentinal caries. The average sensitivity and specificity values for caries detection were 0.69 and 0.65, respectively, while for treatment decisions, the values were 0.56 and 0.65, respectively. Analysis of the relationship between the 39 clinicians’ decision-making and histological examination revealed the average accuracy of the visual-radiographic examination to be 0.67 for caries detection and 0.62 for treatment decision. Inter-examiner agreement for occlusal dental caries in enamel or dentine was moderate ($\kappa=0.42$) while the inter-examiner agreement for treatment decision making was slight ($\kappa=0.29$).

Table 1 presents each dentist’s diagnoses and treatment decisions across both mannequins. The number of teeth deemed to have caries in enamel and in dentine by dentists ranged from 0-20 and 2-25, respectively, when to histological validation revealed there were 8 teeth with carious lesions in enamel and 10 in dentine. The number of teeth thought in need of “non-invasive” treatment ranged from 0 to 23 while for “invasive” treatment this ranged from 4 to 36.

Among the “non-invasive treatments”, no treatment was recommended 471 times, follow-up 283 times then sealant 125 times, topical fluoride application 92 times and fluoride varnish just twice. Among “invasive treatments” amalgam restorations were most often recommended at 298 times closely followed by resin restorations at 223 times with glass ionomer cements and preventive restorations being indicated 52 and 59 times respectively. There was an observed tendency for the dentists to treat lesions considered to be in enamel by using invasive therapeutic procedures; that is, 60% of the decisions they considered as decayed at enamel level received the recommendation of restorative treatment (Table 2).

Treatment costs combined across the two cases ranged from 9 to 65 US\$, mean 32US\$, while the histologically validated cost was 23US\$. This is a 41% spend on unwarranted treatment.

Discussion

Although the method of *in vitro* diagnostic exams is criticised alleging that information collected through a medical history is lost, this method is effective in evaluating the reproducibility of caries detection and treatment planning in groups of examiners (Bader *et al.*, 1994; Espelid and Tveit, 2001; Gray and Paterson, 1997; Mialhe *et al.*, 2009; Reis *et al.*, 2006).

To study caries diagnosis and its treatment among public health dentists is important, because any overtreatment, besides harming patients’ oral health, has financial impacts on the hard pressed public purse (Cunningham, 2000; Norlund *et al.*, 2009).

Inter-examiner agreement for caries detection ($\kappa=0.42$) was close to that found in the study of Mialhe *et al.* (2007) ($\kappa=0.40$), using the same method, among public health service dentists in the interior of the state of Paraná, Brazil, though the agreement over treatment decisions was lower ($\kappa=0.29$ vs. 0.53). However, the teeth used in the earlier research differed from those used in the present study, so

Table 1. Number of teeth for each dentist's caries diagnosis and treatment decisions and their histological validation ranked by treatment cost

Dentist identifica- tion number	Caries Diagnosis			Treatment Decision		Treatment Cost, US\$
	Sound	Enamel	Dentine	Non-invasive	Invasive	
13	36	2	2	0	5	8.70
37	34	4	2	0	5	8.70
38	35	2	3	0	5	8.70
10	30	5	5	1	5	9.34
35	32	4	4	0	6	10.44
14	33	4	3	0	7	12.18
12	23	10	7	3	7	14.10
3	27	8	5	3	8	15.84
36	26	7	7	1	9	16.30
23	20	13	7	8	7	17.30
21	35	1	4	19	4	19.12
11	23	8	9	8	9	20.78
34	24	13	3	6	10	21.24
4	26	10	4	20	5	21.50
19	25	8	7	5	11	22.34
33	22	10	8	1	14	25.00
6	25	12	3	8	14	29.48
5	8	17	15	0	17	29.58
7	22	9	9	1	17	30.22
32	22	4	14	0	18	31.32
26	21	9	10	4	17	32.14
25	22	6	12	8	16	32.79
1	6	20	14	0	19	33.06
27	20	0	20	0	20	34.80
9	21	6	13	4	19	35.62
31	14	11	15	3	22	40.20
20	20	11	9	23	17	44.30
24	18	12	10	10	22	44.68
2	5	14	21	17	21	45.68
29	14	12	14	4	25	46.06
39	15	9	16	6	25	47.34
18	14	14	12	4	26	47.80
22	14	6	20	7	26	49.72
16	10	14	16	2	29	51.74
30	10	18	12	0	30	52.20
17	2	13	25	15	25	53.10
28	13	18	9	14	26	54.20
15	6	19	15	10	28	55.12
8	4	15	21	4	36	65.20
Maximum	36	20	25	23	36	65.20
Mean	20	10	10	6	16	31.74
Minimum	2	0	2	0	4	8.70
(sd)	(9)	(5)	(6)	(6)	(9)	(15.96)
Histological	22	8	10	8	10	22.52

the same mixture of assessments cannot be guaranteed complicating direct comparison of the kappa score values between studies. These variations are in line with other studies such as Gray and Paterson's (1997). In the present study, the high variability in treatment plans could substantially affect the oral health care costs for public health system because of the estimated 41% overtreatment cost compared to the histologically validated treatment cost.

The cost of a true-positive caries diagnosis in dentine, considering the caries detection method and treatment decision, is inversely related to caries occurrence in a low prevalence population (Norlund *et al.*, 2009). In the present study, the public health service dentists tended to overtreat, with 60% of the teeth considered to have (reversible) carious lesions in enamel but being indicated for restorative treatment. The same tendency is evident among private dentists (Espelid and Tveit, 2001; Mialhe *et al.*, 2009; Shugars and Bader, 1996).

Among the invasive treatments, amalgam restoration was the most recommended procedure, following by resin restoration. However, the common use of amalgam is not observed everywhere and there is a widespread and marked tendency for increased use of resin despite findings that single amalgam restorations had the longest survival (Burke and Lucarotti, 2009).

Several factors are considered responsible for inter-examiner variation related to clinical decision making in dentistry, such as curricular differences in pre- and post-graduation training, clinical criteria for dental caries, treatment philosophies taught in schools, patient's race, subjectivity in caries diagnosis and determination of its activity and risk presented by the dentists (Anusavice, 2003; Cabral *et al.*, 2005; Shugars and Bader, 1996; Tubert-Jeanin *et al.*, 2004). Moreover, dentists' uncertainty about patients' adherence to preventive treatment and lack of institutional incentives for dentists to adopt a more preventive approach are possible causes of variability in clinical decision making, to some degree favouring overestimation of invasive treatment (Anusavice, 2003; Tubert-Jeanin *et al.*, 2004). Control of such factors could have a positive impact on the quality of public oral health services through more reliable criteria for caries diagnosis to monitor the oral health status of the population and for planning clinical treatments (Norlund *et al.*, 2009).

This research it may be beneficial for public health service professionals to receive initial training and continuing education to improve the quality of caries diagnosis and treatment recommendations. A partnership between dental schools and health managers promoting continuing health education may encourage adoption of evidence-based clinical protocols to help to reduce these inefficiencies (Jenson *et al.*, 2007; Mialhe *et al.*, 2007; Shugars and Bader, 1996; Tubert-Jeanin *et al.*, 2004).

Table 2. Relationship between histological caries diagnoses and treatment proposals by the public health dentists

Caries	No treatment		Preventive treatment		Restorative treatment		Total n
	n	%	n	%	n	%	
Sound	454	58.4	319	41.1	4	0.5	777
Enamel caries	14	3.7	136	36.0	228	60.3	378
Dentine caries	2	0.5	3	0.7	400	98.8	405

Conclusions

High variability in caries detection and treatment decisions was verified among the public health dentists with an evident tendency to overtreat clinical conditions. This could generate negative impacts on the oral health care of the population and on the cost to public health services.

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