UNIVERSIDADE FEDERAL DE SANTA MARIA
CENTRO DE CIÊNCIAS DA SAÚDE
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS ODONTOLÓGICAS

Ronairo Zaiosc Turchiello

DESEMPENHO DE ESTUDANTES DE GRADUAÇÃO EM ODONTOLOGIA NA DETECÇÃO E AVALIAÇÃO DA ATIVIDADE DE LESÕES DE CÁRIE: REVISÃO SISTEMÁTICA E META-ANÁLISE

Santa Maria, RS
2018

Ronairo Zaiosc Turchiello

DESEMPENHO DE ESTUDANTES DE GRADUAÇÃO EM ODONTOLOGIA NA DETECÇÃO E AVALIAÇÃO DA ATIVIDADE DE LESÕES DE CÁRIE: REVISÃO SISTEMÁTICA E META-ANÁLISE

Dissertação de Mestrado apresentada ao Programa de Pós-Graduação em Ciências Odontológicas, Área de concentração em Odontologia, ênfase em Odontopediatria, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para a obtenção do título de **Mestre em Ciências Odontológicas.**

Orientadora: Profª. Drª. Tathiane Larissa Lenzi

Santa Maria, RS
2018

Turchiello, Ronairo
Desempenho de estudantes de graduação em Odontologia na detecção e avaliação da atividade de lesões de cárie: Revisão sistemática e meta-análise / Ronairo Turchiello.- 2018.
53 p.; 30 cm

Orientadora: Tathiane Larissa Lenzi
Dissertação (mestrado) - Universidade Federal de Santa Maria, Centro de Ciências da Saúde, Programa de Pós Graduação em Ciências Odontológicas, RS, 2018

1. Cárie Dentária 2. Curva ROC 3. Estudantes de Odontologia 4. Sensibilidade 5. Especificidade I. Lenzi, Tathiane Larissa II. Título.

Sistema de geração automática de ficha catalográfica da UFSM. Dados fornecidos pelo autor(a). Sob supervisão da Direção da Divisão de Processos Técnicos da Biblioteca Central. Bibliotecária responsável Paula Schoenfeldt Patta CRB 10/1728.

Ronairo Zaiosc Turchiello

DESEMPENHO DE ESTUDANTES DE GRADUAÇÃO EM ODONTOLOGIA NA DETECÇÃO E AVALIAÇÃO DA ATIVIDADE DE LESÕES DE CÁRIE: REVISÃO SISTEMÁTICA E META-ANÁLISE

Dissertação de Mestrado apresentada ao Programa de Pós-Graduação em Ciências Odontológicas, Área de concentração em Odontologia, ênfase em Odontopediatria, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para a obtenção do título de **Mestre em Ciências Odontológicas.**

Aprovado em 20 de julho de 2018:

_____

Tathiane Larissa Lenzi, Dra. (UFSM)
(Presidente/Orientador)

_____

Anelise Fernandes Montagner, Dra. (IESA)

_____

Carine Weber Pires, Dra. (FSG)

Santa Maria, RS
2018

DEDICATÓRIA

Aos meus pais, Roberto e Rejâne; à minha irmã Roberta; à minha avó Helena. Dedico, também, aos demais avós, Antenor, Cecília e João, os quais não estão entre nós para presenciarem esse momento, entretanto a gratidão pelo carinho e confiança faz-se necessária, sempre.

AGRADECIMENTOS

A elaboração deste trabalho não teria sido possível sem meu próprio empenho e dedicação. Afinal, manter a excelência profissional no consultório, concomitante ao deslocamento e diligência para com os estudos do mestrado foi uma tarefa árdua, mas possível graças ao incentivo e ajuda de pessoas ímpares. Especialmente, agradeço:

- à minha orientadora Tathiane Larissa Lenzi, a qual mesmo sem me conhecer anteriormente à seleção, concedeu-me a chance de trabalhar e aprender (muito) junto a sua pessoa. Cresci academicamente, melhorei minha visão crítica e desenvolvi uma sensibilidade de zelo e cuidados técnicos, simplesmente mimetizando e assimilando aquilo que minha grande "parceira" realizava com maestria. Talvez, eu não tenha correspondido a todas suas expectativas, mas o meu melhor foi empreendido!

- aos meus pais Roberto e Rejâne Turchiello, pelos ensinamentos e apoio incondicionais, desde meus primeiros passos. Ambos representam o real significado de perseverança, bondade e humildade. Amo vocês!

- à minha irmã Roberta Turchiello, pela cumplicidade e afeto que sempre demonstrou. Estaremos sempre próximos e unidos. O "mano" te considera demais!

- à minha tia "do coração" Silvana Vaccari, pela amabilidade, doçura e hospitalidade, desde os primórdios do curso. O sentimento de poder contar com alguém de vasto coração deixa-me honrado. Conte comigo, minha querida tia!

- à minha professora, colega de profissão e amiga Annie Pozeczek Koltermann Saccol, por sempre acreditar em mim e me desafiar no intuito do meu crescimento pessoal e profissional, mostrando-me o mais belo lado da saúde coletiva. Devo muito a você!

- aos meus colegas de graduação: Arthur, Andressa, Laís, Lennon, Nana, Nayany, Renan, Daniel, Juliano e Felipe; e de especialização: Ivam e Gabriel; por vibrarem e torcerem com verdade e empatia. Jamais esquecerei de vocês!

- à minha ex-namorada Rafaela Vaccari – minha amiga, pelo carinho e força. Em todo o momento, recebi uma palavra de ânimo. Ao final, mudamos nossos rumos e mantivemos a admiração.

Enfim, a todos àqueles que durante minha longa jornada fizeram-se presentes e essenciais, aperfeiçoando-me como ser humano e cidadão.

Se amanhã o que eu sonhei não for bem aquilo, eu tiro um arco-íris da cartola. E refaço. Colo. Pinto e bordo. Porque a força de dentro é maior. Maior que todo o mal que existe no mundo. Maior que todos os ventos contrários. É maior porque é do bem. E nisso, sim, acredito até o fim.

(Caio Fernando Abreu)

RESUMO

DESEMPENHO DE ESTUDANTES DE GRADUAÇÃO EM ODONTOLOGIA NA DETECÇÃO E AVALIAÇÃO DA ATIVIDADE DE LESÕES DE CÁRIE: REVISÃO SISTEMÁTICA E META-ANÁLISE

AUTOR: Ronairo Zaiosc Turchiello
ORIENTADORA: Tathiane Larissa Lenzi

A detecção de cárie é um tema essencial no currículo dos cursos de graduação em Odontologia, uma vez que o estabelecimento do diagnóstico é essencial para a correta tomada de decisões clínicas. No entanto, muitos fatores podem influenciar o desempenho do exame visual para tal avaliação, como o treinamento dos examinadores. Isto poderia ser crucial considerando que alunos de graduação ainda não desenvolveram as habilidades diagnósticas necessárias. Sendo assim, esta revisão sistemática e meta-análise objetivou avaliar o desempenho de estudantes de graduação em Odontologia na detecção e avaliação da atividade de lesões de cárie por meio da inspeção visual. Uma ampla pesquisa foi realizada nas bases de dados PubMed/ MEDLINE, Scopus, Lilacs e OpenSINGLE até junho de 2018 para identificar a literatura relacionada à questão de pesquisa. Nenhuma restrição quanto ao ano de publicação ou idioma foi considerada. Dois revisores selecionaram independentemente os estudos, extraíram os dados e avaliaram o risco de viés com a ferramenta *Quality Assessment of Diagnostic Accuracy Studies* (QUADAS-2). As meta-análises sumarizaram os resultados referentes à reprodutibilidade e acurácia (*Summary Receiver Operating Characteristics analysis* [SROC] e *diagnostic odds ratio* [RDOR]), considerando os limiares D1 (todas as lesões) e D3 (apenas lesões em dentina, quando a profundidade foi avaliada, ou lesões cavitadas, quando a integridade da superfície foi considerada). Para a atividade, consideramos superfícies hígidas + lesões de cárie inativas *vs.* lesões de cárie ativas. Meta-regressão também foi realizada para avaliar o efeito de variáveis metodológicas no desfecho. Heterogeneidade foi explorada usando modelos randômicos e análise de meta-regressão. Dos 233 estudos potencialmente elegíveis, 31 foram selecionados para análise de texto completo e 14 foram incluídos na revisão sistemática. A maioria dos estudos incluídos usou o ICDAS (92,9%) para avaliação da severidade e Nyvad (28,6%) para atividade de cárie. Os estudos apresentaram moderados valores agrupados de concordância interexaminadores (0,52; IC95% 0,39-0,66) e substanciais valores agrupados de concordância intra-examinador (0,70; IC95% 0,55-0,86) quando a severidade foi considerada. Substanciais valores agrupados de concordância intra-examinador (0,62; IC95% 0,38-0,86), mas baixos valores agrupados de concordância interexaminadores (0,39; IC95% 0,10-0,67) foram encontrados para avaliação da atividade.Os estudos mostraram moderados valores agrupados de sensibilidade nos limiares D1 (0,640 IC 95% 0,620-0,660) e D3 (0,625 IC95% 0,585-0,664). Excelentes valores agrupados de especificidade foram encontrados nos limiares D1 (0,970 95% CI 0,967-0,973) e D3 (0,984 95% CI 0,982-0,986). A sensibilidade agrupada também foi menor que a especificidade agrupada para atividade de cárie. Em geral, a heterogeneidade foi alta. Todos os estudos incluídos apresentaram alto risco de viés na seleção da amostra. O nível educacional dos estudantes no curso e a experiência clínica prévia não influenciaram na acurácia e reprodutibilidade da inspeção visual. Em conclusão, o desempenho dos estudantes de graduação na detecção de lesões de cárie por meio da inspeção visual foi boa, embora a avaliação da atividade deva ser melhorada.

Palavras-chave: Cárie Dentária. Curva ROC. Estudantes de Odontologia. Odontologia Baseada em Evidências. Sensibilidade e Especificidade.

ABSTRACT

UNDERGRADUATE DENTAL STUDENTS' PERFORMANCE IN DETECTING AND ASSESSING THE ACTIVITY OF CARIES LESIONS: SYSTEMATIC REVIEW AND META-ANALYSIS

AUTHOR: Ronairo Zaiosc Turchiello
ADVISOR: Tathiane Larissa Lenzi

The caries detection is an essential topic in the curriculum of graduation courses in Dentistry, since establishing the diagnosis is essential for the correct clinical decision making. However, many factors can influence the performance of the visual examination, such as the examiners' training. This could be crucial considering the undergraduate students have not yet developed the diagnostic skills. Thus, this systematic review and meta-analysis aimed to evaluate the performance of dental undergraduate students in detecting and assessing the activity status of caries using visual inspection. A comprehensive search was undertaken through PubMed/MEDLINE, Scopus, Lilacs databases and OpenSINGLE up to June 2018 to identify literature related to research question. No publication year or language restriction was considered. Two reviewers independently selected the studies, extracted the data and assessed the risk of bias with Quality Assessment of Diagnostic Accuracy Studies tool (QUADAS-2). Meta-analyses summarized the results concerning reproducibility and accuracy (Summary Receiver Operating Characteristics analysis [SROC], diagnostic odds ratio [DOR], considering D1 (all lesions) and D3 (only lesions into dentin, when lesion depth was assessed, or cavitated lesions, when surface integrity was evaluated) thresholds. For activity, we considered sound surfaces + inactive caries lesions vs. active caries lesions. Meta-regression was also performed to assess the effect of methodological variables on the outcome. Heterogeneity was explored using random-models and meta-regression analysis. The heterogeneity of the studies was also assessed. From 233 potentially eligible studies, 31 were selected for full-text analysis and 14 were included in the systematic review. Most of the included studies used the ICDAS (92.9%) for severity assessment and Nyvad (28.6%) for caries activity. Studies showed moderate values of pooled interexaminer agreement (0.52; 95% CI 0.39-0.66) and substantial pooled values of intra-examiner agreement (0.70; 95% CI 0.55-0.86) when severity was considered. Substantial pooled values of intra-examiner agreement (0.62; 95% CI 0.38-0.86), but poor pooled values of interexaminer agreement (0.39; 95% CI 0.10-0.67) were found for activity assessment. Studies showed moderate values of pooled sensibility at D1 (0.640; 95% CI 0.620-0.660) and D3 (0.625 95% CI 0.585-0.664) thresholds. Excellent values of pooled specificity were found at D1 (0.97 95% CI 0.967-0.973) and D3 (0.984 95% CI 0.982-0.986) thresholds. The pooled sensitivity was also lower than pooled specificity for caries activity. Overall, the heterogeneity was high. All included studies presented a high risk of bias in sample selection. Students' education level in the course and previous clinical experience did not influence on the accuracy and reproducibility of the visual inspection. In conclusion, the undergraduate students' performance in detecting caries lesions using visual inspection was good, although activity status assessment should be improved.

Keywords: Dental caries. ROC curve. Students, Dental. Evidence-Based dentistry**.** Sensitivity and specificity.

SUMÁRIO

1 INTRODUÇÃO

Há uma preocupação iminente na formação de profissionais que não só possuam conhecimento, mas também desenvolvam habilidades para reconhecer cárie dentária como doença e tomar decisões clínicas com base na melhor evidência científica atual (SCHULTE et al., 2011). A detecção das lesões de cárie tem sido colocada como um tema de participação obrigatória nas aulas de Cariologia dos cursos de formação de profissionais na área de Odontologia (PITTS et al., 2011; SCHULTE et al., 2011).

A inspeção visual tem se mostrado um método acurado e confiável para ser utilizado para detecção de lesões de cárie (GIMENEZ et al., 2015). Embora os estudos de acurácia careçam de evidências em alguns desfechos clínicos de relevância importante (GIMENEZ et al., 2015), a possibilidade de sua utilização como método principal para detecção de lesões de cárie vem sendo aventada (BRAGA et al., 2010), devido a sua possibilidade de reconhecimento de características das lesões importantes de serem levadas em consideração para a decisão de tratamento, já que podem interferir no prognóstico (e/ou na progressão) das mesmas.

Uma revisão sistemática recente mostrou que o uso de índices tende a melhorar a acurácia do exame visual para detecção de lesões de cárie (GIMENEZ et al., 2015). Neste sentido, o uso do *International Caries Detection and Assessment System* (ICDAS) seria uma alternativa para se utilizar clinicamente. O índice contempla a avaliação das lesões de cárie desde o seu estágio mais inicial de desenvolvimento (lesões não cavitadas) até cavitações mais extensas (PITTS, 2004). A abordagem das lesões iniciais é importante para o estabelecimento de condutas de diagnóstico e terapêutica adequadas e garante um melhor prognóstico no tratamento da doença (NYVAD, 2004).

O ICDAS, entretanto, não foi desenvolvido para avaliação da atividade da doença. Assim, critérios para avaliação da atividade foram propostos para serem usados em associação com o ICDAS. Um deles consiste na ponderação mental de algumas características clínicas de lesões ativas e inativas em esmalte e dentina que podem ser avaliadas em uma única sessão. Já o *Lesion Activity Assessment* (LAA) é baseado na combinação de parâmetros clínicos relacionados à lesão como: a aparência visual da lesão (ICDAS), propensão local à estagnação de placa e a

textura da superfície (EKSTRAND et al., 2007). Para cada um deles, há pontos específicos para serem atribuídos, sendo a soma desses pontos a forma de classificação dessas lesões, quanto à atividade. Assim, a partir de um ponto de corte estabelecido em estudos prévios, pontuação acima de 7 indica presença de lesão ativa. O uso do LAA poderia reduzir a subjetividade na avaliação, sendo uma vantagem promissora.

De fato, uma recente revisão sistemática tem demonstrado que o ICDAS possui substancial reprodutibilidade na avaliações da severidade da doença. Sistemas adicionais associados ao ICDAS que classificam a atividade de cárie podem ser úteis, uma vez que apresentam moderada reprodutibilidade (EKSTRAND et al., 2018). No entanto, muitos fatores podem influenciar o desempenho do exame visual associado ou não ao uso de índices para detecção e avaliação da atividade de cárie, como o treinamento dos examinadores. Isto poderia ser crucial considerando que estudantes de graduação ainda não desenvolveram as habilidades diagnósticas necessárias.

A etapa de diagnóstico de cárie tem sido apontada por estudantes de graduação como um processo de difícil assimilação e aprendizado (LARA et al., 2015). Além disso, eles podem ser incapazes de perceber sutis alterações que poderiam ser um indicativo da presença e/ou atividade da doença no paciente (ZANDONÁ et al., 2009). Estudos prévios (ZANDONÁ et al., 2009; BUSSANELI et al., 2015; ASSAF et al., 2006) têm demonstrado boa reprodutibilidade entre estudantes de graduação na detecção de lesões de cárie em estágios mais avançados. No entanto, alta reprodutibilidade não necessariamente implica na correta tomada das decisões clínicas. Por outro lado, não há consenso na literatura sobre o desempenho de estudantes de graduação na detecção de lesões iniciais (ZANDONÁ et al., 2009; EL-DAMANHOURY et al., 2014).

O desempenho dos estudantes de graduação na detecção de lesões de cárie também pode ser influenciado por uma série de fatores, como o nível no curso, experiência clínica prévia e o método de ensino utilizado. Examinadores menos experientes, ou seja, cursando semestres iniciais, são geralmente associados a resultados falso-positivos (EL-DAMANHOURY et al., 2014).

Tem sido demonstrado que o *e-learning* pode melhorar algumas habilidades diagnósticas (DINIZ et al., 2010). O uso de dentes extraídos e fotografias também tem sido investigado como estratégia de treinamento para detecção de lesões de

cárie (ZANDONÁ et al., 2009; FOLEY et al., 2012; EL-DAMANHOURY et al., 2014; LUZ et al., 2014) e divergências no desempenho de estudantes de graduação na detecção de lesões de cárie tem sido encontradas quando da utilização desses recursos.

Diante do exposto, é relevante a realização de uma revisão sistemática e meta-análise para investigar o desempenho de estudantes de graduação em Odontologia na detecção e avaliação da atividade de cárie por meio da inspeção visual, bem como, os fatores metodológicos que podem influenciar as habilidades diagnósticas.

2 ARTIGO - Does undergraduate dental students perform well detecting and assessing caries activity? A systematic review and meta-analysis

Este artigo será submetido ao periódico *Journal of Dental Education* (ISSN: 0022-0337) - Fator de Impacto: 0,63; Qualis CAPES A2. As normas para publicação estão descritas no ANEXO A.

Does undergraduate dental students perform well detecting and assessing caries activity? A systematic review and meta-analysis

Ronairo Z. Turchiello
MSc Student
Graduate Program in Dental Science, Federal University of Santa Maria, Brazil

Djessica Pedrotti
MSc Student
Graduate Program in Dental Science, Federal University of Santa Maria, Brazil

Mariana M. Braga
Associate Professor
Department of Orthodontics and Pediatric Dentistry, School of Dentistry, University of Sao Paulo, Brazil

Rachel de O. Rocha
Associate Professor
Department of Stomatology, Federal University of Santa Maria, Brazil

Jonas A. Rodrigues
Assistant Professor
Department of Surgery and Orthopedics, Federal University of Rio Grande do Sul, Brazil

Tathiane L. Lenzi
Assistant Professor
Department of Surgery and Orthopedics, Federal University of Rio Grande do Sul, Brazil
Graduate Program in Dental Science, Federal University of Santa Maria, Brazil

✉**Corresponding author:**

Tathiane L. Lenzi
Graduate Program in Dental Science, Federal University of Santa Maria, Brazil
Rua Marechal Floriano Peixoto, 1184, 97015-270, Santa Maria, RS, Brazil
Phone: +55 55 3220 9266 E-mail address: tathilenzi@hotmail.com

Abstract

This study aimed to systematically assess the undergraduate dental students' performance in detecting and assessing caries activity status using visual inspection. Two independent reviewers searched the literature through PubMed/MEDLINE, Scopus, Lilacs databases and OpenSINGLE up to June 2018. Risk of bias was assessed using QUADAS-2. Meta-analyses summarized the results concerning reproducibility and accuracy at D1 and D3 levels. For activity, we considered sound surfaces plus inactive caries lesions vs. active caries lesions. In addition, meta-regression was performed to assess the effect of methodological variables on the outcomes. A total of 14 studies were included, most of them using ICDAS (92.9%) for assessing severity and Nyvad system (28.6%) for assessing caries activity status. The mean reproducibility values were ≥0.52, except for interexaminer agreement when assessing caries activity status (0.39; 95% CI 0.10-0.67). The intra-examiner reproducibility tended to be higher than the interexaminer reproducibility. Overall, undergraduate students' performance in staging caries lesions using visual examination was good (AUC>0.85 and DOR>25). The sensitivity values were moderate; however, these were associated with excellent specificity values. Despite few pooled studies, assessment of caries activity status revealed moderate overall performance, with lower pooled sensitivity than pooled specificity. Students' education level and background clinical experience had no influence on the accuracy and reproducibility of the visual inspection. Studies presented a high bias risk in sample selection. Concluding, undergraduate dental students' performance in detecting and staging caries using visual inspection was good, although caries activity assessment still requires improvement.

Keywords: Students, Dental. Dental caries. Detection. Diagnosis. Reproducibility. Sensitivity and specificity. Evidence-Based dentistry

Introduction

Caries detection is an essential competence to be developed during undergraduate dental education[1], since it is strongly linked to the appropriate choice for treatment[2]. Dental students are supposed to be competent in collecting data at different stages of the caries process[3], as well as classifying them[1].

Thus, visual inspection seems to be the most complete option available[4], offering good to acceptable performance even if not associated with other methods[5]. However, the examiners' experience may impact on their performance[5]. Actually, the use of visual inspection during the graduation course implies in the student's development of practical skills, since, in this period, the students are still understanding the differences between sound surfaces and those presenting clinical signs of caries disease.

Indeed, the stage of caries diagnosis has been considered a process of difficult assimilation and learning by undergraduate students [6]. Moreover, students may be unable to notice more discrete changes that may indicate the caries activity status in the patient[7]. The undergraduate students' performance in detecting caries lesions also may be influenced by several factors such as education level, clinical experience and teaching method. Less experienced examiners, i.e., attending first years, are usually associated with false positive results[8].

In addition, it has been reported that teaching strategies such as e-learning may improve some diagnostic skills[9]. On the other hand, the impact of laboratorial training with extracted teeth and dental images on students' performance in detecting

caries lesions is not clear yet[8,10]. To the best of our knowledge, no previous studies have conducted a systematic review and meta-analysis to specifically evaluate the undergraduate students' performance in detecting caries and methodological factors that may influence the diagnostic skills.

Therefore, this systematic review and meta-analysis aimed to investigate the undergraduate dental students' performance in detecting and assessing caries activity using visual inspection and potential sources of interference and risk of bias in this process.

Methods

This systematic review was written according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement[11] and registered in the International Prospective Register of Systematic Review (PROSPERO: CRD 42017070566).

Search strategy

A comprehensive literature search was undertaken through PubMed/MEDLINE, Scopus and Lilacs databases to identify literature up to June 2018 related to research question. The search was conducted with no limits in publication year or language. The subject search used a combination of controlled vocabulary and text words based on the search strategy for the PubMed/MEDLINE database as follow:

((((((undergraduate dental education) OR undergraduate education) OR undergraduat*) OR student*) OR undergraduate dental student*)) AND (((((((((dental caries[MeSH Terms]) OR dental caries) OR dental decay) OR caries) OR cario*) OR tooth decay) OR teeth decay) AND detection))

A sensitive search strategy was adapted for Scopus and Lilacs databases. In addition, OpenSIGLE was accessed to retrieve unpublished literature. The search results of various databases were cross-checked to locate and eliminate duplicates.

Study Selection and Eligibility Criteria

Two reviewers (DP and RZT) independently assessed the identified publications that assessed the performance of undergraduate dental students for caries detection and selected them, initially, by title and abstract. The interexaminer agreement was calculated (Kappa = 0.92), which indicated excellent agreement. In order to retrieve all relevant papers, reference lists of the included papers and related reviews were also screened.

The final decision about inclusion was made based on the full-text of the potentially relevant studies. We excluded from the final sample studies that: 1) did not use visual inspection for caries detection; and 2) did not report the undergraduate dental students' performance (any measurement of accuracy, i.e., sensitivity, specificity, number of correct diagnosis and/or any measurement of agreement, i.e., repeatability, reproducibility) as outcome. Any discrepancies between reviewers were solved through discussion and consensus of a third reviewer (TLL).

Data collection

A protocol for data extraction was defined. Two reviewers (DP and RZT) independently collected the data of the eligible studies. For each paper, the following data were systematically extracted: publication year, country, participants (number of undergraduate students, year in the course), learning activities, use or not of criteria for visual examination, material used for performance assessment (extracted teeth, photographs, patients), number of evaluations performed, study setting, reference standard, and all data related to a relevant outcome (reproducibility, sensitivity,

specificity, accuracy, absolute number of true positives, false positive, true negatives, and false negatives). If the study presented any estimation of variance, they were also registered. If not, the standard error was estimated using a graphical model[12]. When papers assessed the students' performance before and after any learning or training process, data were considered separately, considering, respectively, the educational background exposure of students.

Risk of Bias of Individual Studies

The QUADAS-2 checklist[13] (i.e., quality assessment of studies of diagnostic performance included in systematic reviews) was used to assess the risk of bias of the included studies. Data were assessed and collected by 2 reviewers (MMB and TLL). According to four domains (sample selection, index test, reference standard, or timing and flow), the studies were classified as low, high, or unclear risk of bias. The first three domains were also assessed in terms of concerns regarding applicability. Risk of bias assessment was performed only for papers that reported accuracy data.

Summary measures and synthesis of results

Meta-analyses for accuracy were performed separately at two different thresholds according to the reference standard assessment: D1 (considering all lesions, independent of lesion depth or dental surface integrity) and D3 (including only lesions into dentin, when lesion depth was assessed or cavitated lesions, when surface integrity was evaluated). For activity, we considered sound surfaces plus inactive caries lesions vs. active caries lesions.

Statistical pooling of sensitivity, specificity, diagnostic odds ratio (DOR), and positive and negative likelihood ratios was carried out using the DerSimonian Laird method (random effects meta-analysis models), considering the aforementioned thresholds (MetaDisc 1.4 MetaDisc 1.4 Software, Unidad de Bioestadistica Clínica

del Hospital Ramón y Cajal, Madrid, Spain).

Meta-analyses for intra-and interexaminer reproducibility were performed considering caries severity and activity (R package metaphor, GNU General Public License Version 2) using random-effects models. Coefficients were pooled according to the methodology of a previously published study[14], since they can be considered mathematically similar. The presence of heterogeneity was analyzed via Cochran's Q test and inconsistency (I^2) based on DORs and pooled agreement estimates of included studies.

We conducted meta-regression analyses to investigate the effect of methodological differences, such as education level, clinical experience, learning activities, reference standard method used in the validation and study setting, on the studied outcomes.

The threshold effects were tested the Moses-Shapiro-Littenberg method. For meta-regression analysis, DOR values were used as the outcome measure. Relative diagnostic odds ratio (RDOR) values and 95% confidence intervals (CI) in relation to the reference category of the independent variables were calculated for each condition to estimate the effect of each variable on the accuracy of the method. The chosen method for estimating variance among studies was the Restricted Maximum Likelihood (REML) method and possible threshold effect, whenever present, were considered in the analysis. In the models, studies were weighted according to weighted least squares method, using the inverse of variance of the log of the DOR. Different models were created for each tested variable and statistical significance was set at 0.05.

Publication bias was assessed by checking the asymmetry of funnel plots visually and using regression analysis performed in the R package metafor (GNU

General Public License Version 2). Alternatively, for accuracy, we used funnel plots of (natural logarithm (ln) DOR) vs. (1/√effective sample size)).

Results

Study selection

The search strategy identified 233 potentially relevant papers, excluding duplicates. After screening titles and abstracts, we retrieved 32 full-text papers for more detailed information. Finally, 14 papers met the eligibility criteria and were included in this systematic review. The flow diagram summarizes the process of studies selection and the reasons for exclusions (Figure 1).

Study characteristics

The characteristics of the included studies are presented in Table 1. Undergraduate dental students from different years were included in the reviewed studies. None of the studies performed the sample size calculation and the majority of studies were performed in Brazil[9,15–20]. The ICDAS criteria were often the chosen for staging caries lesion severity and Nyvad system for assessing caries lesion activity status. However, students' performance for caries activity was tested in only 42.9% of the studies.

Different educational strategies were used prior to students' assessment such as traditional lecture (classroom activities) associated or not with ICDAS e-learning, simulated training with extracted teeth, or training using dental images. Most studies presented reproducibility, sensitivity, specificity, and accuracy results. However, three studies calculated only reproducibility[8,10,17] and one study did not report reproducibility data[18]. The number of correct responses was additionally described in one study[8].

In the majority of the studies, to assess the undergraduate students' performance, extracted teeth were employed using histology as validation. Three studies performed clinical evaluation of children with primary or mixed dentition[16,18,19]. For these studies, validation was clinical consensus among experts.

Some papers considered different thresholds such as all lesions or only cavitated lesions for evaluating the students' performance[18–21]. Regarding caries lesion activity status, clinical consensus was used as reference standard. Only two studies investigated the treatment decision based on caries detection[16,20].

Synthesis of results

Intra- and interexaminer agreement considering severity and activity assessment is displayed in Figures 2 and 3, respectively. Eight studies assessed examiner agreement while nine papers evaluated intra-examiner agreement for severity. Only three studies evaluated intra- and interexaminer reproducibility for caries activity.

For severity, studies showed moderate values of pooled interexaminer agreement (0.52; 95% CI 0.39-0.66) and substantial pooled values of intra-examiner agreement (0.70; 95% CI 0.55-0.86). Substantial pooled values of intra-examiner agreement (0.62; 95% CI 0.38-0.86), but poor pooled values of interexaminer agreement (0.39; 95% CI 0.10-0.67) were found for activity assessment.

Pooled sensitivity, specificity, DOR, positive and negative likelihood ratios, I^2, and summary receiver operating characteristics curves were calculated for severity and activity as presented in Figures 4 and 5, respectively.

Eleven studies reported the accuracy at the D1 threshold and nine papers for that at the D3 threshold. Overall, undergraduate students' performance for staging caries lesions using visual examination was good (AUC>0.85 and DOR>25).

Although moderate sensitivity values were found, they were associated to excellent specificity values. The lowest sensitivity values were observed among studies that used clinical setting to assess students' performance.

Despite few pooled studies, a moderate overall performance was observed when activity status of caries lesion was assessed (see area under SROC, Figure 5). Besides, the pooled DOR was close to 12. Both for severity and activity, pooled sensitivity was lower than pooled specificity. Overall, the heterogeneity was high (I^2 > 80%) considering all analyses performed.

Meta-regression results are presented in Table 2. Education level and previous clinical experience had no influence on both accuracy and reproducibility of the visual examination performed by undergraduate students. Face-to-face learning activities impacted on students' performance in terms of accuracy at D1 threshold and interexaminer agreement. Moreover, study setting and reference standard had influence on the visual examination performance, only when accuracy was considered.

Through funnel plots analyses (online suppl. Fig. S1), we did not identify the occurrence of publication bias when testing the accuracy (D1; p=0.2067 and D3; p= 0.0528 thresholds) as well as interexaminer (p=0.1758) and intra-examiner (p=0.0749) agreement for severity. Publication bias for activity was not performed because few studies were included.

Risk of bias

The main source of risk of bias within the included studies was related to sample selection (Table 3). This observation was true both for accuracy in assessing caries lesion severity and activity. Included studies raised concerns regarding the applicability, when considering sample selection, as they did not clearly indicate if the

spectrum of caries present in the study sample matched the expected prevalence in the target population. Studies that investigated the students' performance for assessing caries activity status did not use a longitudinal design, showing a high risk of bias in the reference standard, and flow and timing domains.

Discussion

Caries lesions detection has been indicated as a required topic in the Cariology classes of Dental Education[3]. In daily clinical practice, it is mainly performed by visual examination[22] because it is a simple and low-cost technique. Some experts have reported the difficulties in classifying clinical characteristics of carious lesions due to the subjective nature of the visual inspection, especially considering their initial signs[22]. Besides, many aspects could have influence on performance of visual examination, as examiners' training[5]. This could be crucial mainly because undergraduate students have not developed their diagnostic skills yet.

Differently from hypothesized, both education level and background clinical experience in dental education process did not influence on the accuracy and reproducibility when students used the visual examination. It may be caused by the utilization of a validated system for detecting and assessing the activity status of caries lesions since it provides practitioners a guideline on characterization of the lesions that they identify and it provides a rational shortcut associating with these characteristics[5]. Except in one included study[23], ICDAS was used for caries inspection. It has been demonstrated that the use of detailed and validated methods improves the accuracy of the visual inspection[5]. On the other hand, one should consider that most studies selected determined students to participate in their

assessments. These students may present several differences considering a general sample of undergraduate students, including individual skills such as knowledge, interest and practical abilities.

In our study, face-to-face learning activities impacted on students' performance in terms of D1 threshold and interexaminer agreement. The didactic activities aid undergraduate dental students in the process of caries diagnosis, mainly for assessing initial lesions that may create more doubts and induce more considerable variability between the examiners[24]. Besides theoretical classes, practical training with extracted teeth and/or dental images may be essential for the development of these specific skills[25]. The laboratory activities systematically provide opportunities for undergraduate dental students to experience different simulated situations covering a variety of circumstances that they should be able to solve in clinical practice. Moreover, in contrast to virtual activities such as e-learning, practical training allows interaction between student-teacher[26], thus improving the educational outcome. For accuracy, study setting and reference standard had influence on the performance.

The SROC curves pooled in the meta-analysis use thresholds to present the results, permitting an overall appreciation of method performance by means of DOR, combining sensitivity and specificity[27]. Values of SROC, sensitivity and specificity were similar between D1 and D3 levels. Although overall good performance for visual inspection has been observed among undergraduate dental students, the separate interpretation of sensitivity and specificity values could contribute to a better understating of areas that could be improved in learning/teaching processes and also, in further researches.

High sensitivity is normally obtained at the expense of reduced specificity,

which could lead to an increase in the number of false-positive caries diagnoses, which in turn could result in overtreatment of a generally slow-progressing disease. Therefore, it is more adequate that a method of caries detection present a high specificity even at the expense of a small reduction in sensitivity[28].

Pooled specificity tended to show greater values than those of pooled sensitivity, irrespective of the assessment (severity or activity), which is a positive finding considering further students' clinical practice wherein false-positive results and overtreatments could be avoided[29]. The lower sensitivity values were mainly related to studies performed in clinical setting, possibly due to difficulties associated with examining under natural conditions. Clinical examinations in children can present other difficult besides presence of plaque and saliva, such as child's behavior and limited mouth opening. Furthermore, approximal lesions are observe under visual inspection, mainly by less experienced examiners.

All included studies presented a high risk of bias in sample selection since that the spectrum of sample disease does not always reflect the disease in the population. In general, samples are usually chosen based on suspicious sites, which are likely to be more difficult for undergraduate dental students to detect, and a larger proportion of such lesions are included than are found in the actual clinical setting. The histological examination that was most commonly used as reference standard in the included studies is able to detect small mineral changes in dentin, even in non-cavitated lesions. However, this alteration was not detectable by clinical examination, leading to a false-negative result and higher values of sensitivity. This was less evident at D3 threshold.

For the caries activity assessment, the available evidence is still limited because only three studies were included in the analyses. Two methods of assessing

the caries activity status have been published for use associated with the ICDAS scoring system[30]. One method is based on a descriptive theory of cognitive processes (clinical features related to active and inactive lesions), while the other is based on prescriptive theories (lesions activity assessment - LAA) [31]. LAA is performed by assigning numerical values (points) to three clinical parameters: visual appearance, whether the lesion is in a plaque stagnation area, and surface texture. The sum of these three independent scores is then used to determine whether the lesion is active or arrested[30]. In addition, Nyvad criteria have been proposed for differentiating lesion activity through condition of brightness/opacity, surface texture, and plaque stagnation[32].

Although LAA seems to overestimate the caries activity assessment of cavitated lesions compared to Nyvad, both criteria showed good association in caries activity assessment[33], since both take into consideration similar clinical features. Studies that investigated the undergraduate students' performance in assessing the caries activity status used clinical consensus as validation.

Predictive validation is the ideal strategy for evaluating the ability to correctly assess the caries activity status[2] , since we can determine if future events are in accordance with the expected ones. Nevertheless, it takes more time and effort, since it is very difficult to perform in studies involving many undergraduate dental students.

Better accuracy of undergraduate dental students in detecting caries lesions than in assessing activity status can be seen in this systematic review. It may be attributed to higher difficulty and inherent subjectivity for assessing caries activity even using validated criteria. Included studies used children and photographs for performing this evaluation. The use of photographs can reduce the specificity

because of overestimation of tooth size or lesion site. Since caries activity is a dynamic process, fully reproducing its evaluation in the laboratory setting is a complicated task.

The high heterogeneity (I^2 > 80%), was possibly due to the high risk of methodological bias observed in most studies, mainly related to sample collection and disparities in threshold for a positive result for the diagnostic or reference standard utilized. We did not identify the occurrence of publication bias. However, it should be interpreted with caution, as a minimum of 10 studies would be necessary in the meta-analysis to have adequate power to detect a real asymmetry[34].

This first systematic review and meta-analysis that compiling results of visual inspection for caries detection using visual inspection showed that the undergraduate students' performance can be good in detecting and staging caries lesions; however, the result could be influenced by certain methodological factors which need to be considered when analyzing and designing further studies. In addition, caries activity assessment by undergraduate dental students should be improved. More training time and clinical experience are necessary to improve the performance for assessing the activity status of caries lesions.

Conclusion

Undergraduate dental students' performance was good in detecting and staging caries lesions using inspection visual, although assessment of the caries activity status should be improved. Most published studies were performed in a laboratory setting and used a convenience sample, including "specific groups" of students. These factors exert a significant influence on the overall accuracy and reproducibility values of the visual inspection.

References

1. Schulte AG, Buchalla W, Huysmans MC, et al. A survey on education in cariology for undergraduate dental students in Europe. Eur J Dent Educ 2011;1:3-8.

2. Baelum V, Heidmann J, Nyvad B. Dental caries paradigms in diagnosis and diagnostic research. Eur J Oral Sci 2006;114(4):263–77.

3. Schulte AG, Pitts NB, Huysmans MC, Splieth C, Buchalla W. European Core Curriculum in Cariology for Undergraduate Dental Students. Caries Res 2011;45(4):336–45.

4. Braga MM, Mendes FM, Ekstrand KR. Detection Activity Assessment and Diagnosis of Dental Caries Lesions. Dent Clin Noth Am 2010;54(3):479–93.

5. Gimenez T, Piovesan C, Braga MM, et al. Visual Inspection for Caries Detection: A Systematic Review and Meta-analysis. J Dent Res 2015;94(7):895–904.

6. Lara JS, Braga MM, Shitsuka C, Wen CL, Haddad AE. Evaluation for Health Professions Dental students ' and lecturers ' perception of the degree of difficulty of caries detection associated learning topics in Brazil. J Educ Eval Health Prof 2015. doi: 10.3352/jeehp.2015.12.56

7. Zandona AGF, Al-Shiha S, Eggertsson H, Eckert G. Student Versus Faculty Performance Using a New Visual Criteria for the Detection of Caries on Occlusal Surfaces: An *In Vitro* Examination with Histological Validation. Oper Dent 2009;34(5):598–604.

8. El-Damanhoury H, Fakhruddin K, Awad M. Effectiveness of teaching International Caries Detection and Assessment System II and its e-learning program to freshman dental students on occlusal caries detection. Eur J Dent 2014;8(4):493–7.

9. Diniz MB, Lima LM, Santos-Pinto L, Eckert GJ, Zandoná AGF, de Cássia Loiola Cordeiro R. Influence of the ICDAS e-learning program for occlusal caries detection on dental students. J Dent Educ 2010;74(8):862–8.

10. Foley JI. Dental students consistency in applying the ICDAS system within paediatric dentistry. Eur Arch Paediatr Dent 2012;13(6):319–22.

11. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med 2009;6(7):e1000100.

12. Hanley JA. Standard error of the kappa statistic. Psychol Bull 1987;102(2):315–21.

13. Whiting PF, Rutjes AWS, Westwood ME, et al. QUADAS-2: A Revised Tool for the Quality Assessment of Diagnostic Accuracy Studies. Ann Intern Med 2011;155(8):529–36.

14. Bornmann L, Mutz R, Daniel HD. A reliability-generalization study of journal peer reviews: a multilevel meta-analysis of inter-rater reliability and its determinants. PLoS One 2010;5(12):e14331.

15. Nogueira VK, Bussaneli DG, Tagliaferro EP, Spin-Neto R, Escobar A, Cordeiro RC. Examiner's experience and the outcome interpretation of ICDAS and Nyvad's system – a prospective *in vitro* study. Acta Odontol Scand 2017;75(3):186–90.

16. Nogueira VK, Bussaneli DG, Restrepo MR, et al. Caries treatment decisions among undergraduate and postgraduate students supported by visual detection systems. Int J Paediatr Dent 2018;28(1):92-101.

17. Silva PF, Forte FDS, Chaves AMBP, Farias IAP, Castro KS. Reproducibility of caries diagnosis in permanent teeth according to WHO, ICDAS-II and Nyvad criteria. Brazilian J Oral Sci 2012;11(1):25–9.

18. Luz PB, Stringhini CH, Otto BR, et al. Performance of undergraduate dental students on ICDAS clinical caries detection after different learning strategies. Eur J Dent Educ 2015;19(4):235–41.

19. Gimenez T, Bittar D, Piovesan C, et al. Influence of Examiner Experience on Clinical Performance of Visual Inspection in Detecting and Assessing the Activity Status of Caries Lesions. Oper Dent 2013;38(6):583–90.

20. Bussaneli DG, Boldieri T, Diniz MB, Lima Rivera LM, Santos-Pinto L, Cordeiro RC. Influence of professional experience on detection and treatment decision of occlusal caries lesions in primary teeth. Int J Paediatr Dent 2015;25(6):418–27.

21. Neuhaus KW, Jost F, Perrin P, Lussi A. Impact of different magnification levels on visual caries detection with ICDAS. J Dent 2015;43(12):1559–64.

22. Bader JD, Shugars DA, Bonito AJ. A systematic review of the performance of methods for identifying carious lesions. J Public Health Dent 2002;62(4):201–13.

23. Souza-Zaroni WC, Ciccone JC, Souza-Gabriel AE, et al. Validity and reproducibility of different combinations of methods for occlusal caries detection: An in vitro comparison. Caries Res. 2006;40(3):194–201.

24. Assaf AV, de Castro Meneghim M, Zanin L, Tengan C, Pereira AC. Effect of different diagnostic thresholds on dental caries calibration - a 12 month evaluation. Community Dent Oral Epidemiol 2006;34(3):213–9.

25. Cowpe J, Plasschaert A, Harzer W, Vinkka-Puhakka H, Walmsley AD. Profile and competences for the graduating European dentist - update 2009. Eur J Dent Educ 2010; 14(4):193–202.

26. Chen T, MdYunus A, Ali WZW, Bakar A. Utilization of Intelligent Tutoring System in mathematics learning. Int J Educ Dev using Inf Commun Technol 2008;4(4):50–63.

27. Glas AS, Lijmer JG, Prins MH, Bonsel GJ, Bossuyt PMM. The diagnostic odds

ratio: a single indicator of test performance. J Clin Epidemiol 2003;56(11):1129–35.

28. Downer MC. Validation of methods used in dental caries diagnosis. Int Dent J 1989;39(4):241–6.

29. Baelum V. Caries management: technical solutions to biological problems or evidence-based care? J Oral Rehabil 2008;35(2):135–51.

30. Ekstrand KR, Martignon S, Ricketts DJN, Qvist V. Detection and Activity Assessment of Primary Coronal Caries Lesions: A Methodologic Study. Oper 2007;32(3):225–35.

31. Gowda D, Lamster IB. The Diagnostic Process. Dent Clin North Am [Internet]. 2011;55(1):1–14.

32. Nyvad B, Baelum V. Nyvad Criteria for Caries Lesion Activity and Severity Assessment: A Validated Approach for Clinical Management and Research. Caries Res 2018;52(5):397–405.

33. Braga MM, Ekstrand KR, Martignon S, Imparato JCP, Ricketts DNJ, Mendes FM. Clinical Performance of Two Visual Scoring Systems in Detecting and Assessing Activity Status of Occlusal Caries in Primary Teeth. Caries Res 2010];44(3):300–8.

34. Sterne JA, Egger M, Moher D. Addressing Reporting Biases. Cochrane Handbook for Systematic Reviews of Interventions. UK: John Wiley & Sons, Ltd. p. 297–333.

35. Parviainen H, Vähänikkilä H, Laitala M-L, Tjäderhane L, Anttonen V. Evaluating performance of dental caries detection methods among third-year dental students. BMC Oral Health 2013;13(1):70.

36. Jablonski-Momeni A, Busche JF, Struwe C, et al. Use of the international caries detection and assessment system two-digit coding method by predoctoral dental students at Philipps University of Marburg, Germany. J Dent Educ 2012;76(12):1657–66.

Table 1. Summary of included studies in the systematic review.

Study	Country	Subjects	Learning activities	Visual criteria	Material used for performance assessment	Reference standard	Outcome	Thresholds
Nogueira et al., (2018)[16]	Brazil	Undergraduate students 5rd year; n=4, without previous experience in ICDAS and Nyvad	Theoretical class and training on photographs	ICDAS and Nyvad	Children (n=25) ICDAS (n=300 surfaces) Nyvad (n=111 surfaces)	Clinical consensus	Interexaminer reproducibility Sensitivity Specificity Accuracy	D1 Sound surfaces + inactive caries lesions vs. active caries lesions
Nogueira et al., (2017)[15]	Brazil	Undergraduate students 2rd year; n=12, without clinical and theoretical experience	Theoretical class	ICDAS and Nyvad	Photographs of primary and permanent teeth (n=77)	Clinical consensus	Intra and interexaminer reproducibility Sensitivity Specificity Accuracy	D3 Sound surfaces + inactive caries lesions vs. active caries lesions
Bussaneli et al., (2015)[20]	Brazil	Undergraduate students 2nd year; n=3	Theoretical class, simulated and virtual training	ICDAS	Primary teeth (n=77)	Histology	Intra and interexaminer reproducibility Sensitivity, Specificity, Accuracy	D1, D3
Luz et al., (2015)[18]	Brazil	Undergraduate students 4th year; n=39	Theoretical class, virtual training, virtual training + ICDAS e-learning tool	ICDAS	Children (n=12)	Clinical consensus	Specificity, Sensitivity Accuracy	D1, D3
Neuhaus et al., (2015)[21]	Switzerland	Undergraduate students 3rd year; n=5, without clinical experience 4th year; n=5, one year of clinical experience	Virtual and simulated training	ICDAS	Permanent teeth (n=100)	Histology	Intra and interexaminer reproducibility Sensibility Specificity Accuracy	D1, D3

El-Damanhoury et al., (2014)[8]	Egypt	Freshmen undergraduate students; n=84	Theoretical class, simulated and virtual training	ICDAS	Permanent teeth (n=72)	Histology	Intra and interexaminer reproducibility Correct answers (%)	
Gimenez et al., (2013)[19]	Brazil	Undergraduate Students; n=2	Theoretical class and simulated training	ICDAS + LAA or activity (clinical characteristics)	Children (n=18)	Clinical consensus	Interexaminer reproducibility Sensitivity Specificity Accuracy	D1, D3 Sound surfaces + inactive caries lesions vs. active caries lesions
Parviainen et al., (2013)[35]	Finland	Undergraduate students 3rd year; n=57	Theoretical class and virtual training	ICDAS and Nyvad	Permanent teeth (n=27)	Histololy (ICDAS) Clinical consensus (Nyvad)	Interexaminer reproducibility Sensibility Specificity Accuracy	D3 Sound surfaces + inactive caries lesions vs. active caries lesions
Foley (2012)[10]	United Kingdom	Undergraduate students 2rd year; n=23 3rd year; n=18 4rd year; n=15	Theoretical class and virtual training	ICDAS	Primary and permanent molars (n=40)	Clinical consensus	Intra and interexaminer reproducibility	
Jablonski-Momeni et al., (2012)[36]	Germany	Undergraduate students 3rd year; n=24	Theoretical class and simulated training	ICDAS	Permanent teeth (n=36)	Clinical consensus	Intra and interexaminer reproducibility Accuracy	
Silva et al., (2012)[17]	Brazil	Undergraduate students 4th year; n=2	Clinical training	WHO, ICDAS and Nyvad	Permanent teeth (n=20)	Clinical consensus	Interexaminer reproducibility	
Diniz et al., (2010)[9]	Brazil	Undergraduate students 5th year; n=8	Theoretical class, virtual and simulated training	ICDAS	Permanent teeth (n=104)	Histology	Intra and interexaminer reproducibility Sensibility Specificity Accuracy	D1
Zandona et al., (2009)[7]	USA	Undergraduate students; n=10	Theoretical class and simulated training	ICDAS + activity (clinical characteristics)	Permanent (n=60)	Histology	Intra and interexaminer reproducibility Sensibility Specificity Accuracy	D1 Sound surfaces + inactive caries lesions vs. active caries lesions

Souza-Zaroni et al., 2006[23]	Brazil	Undergraduate Students; n=3	Training on photographs	No criteria	Permanent teeth (n=47)	Histology	Intra and interexaminer reproducibility

Virtual training: ICDAS e-learning; Simulated training: training with extracted teeth.

Table 2. Meta-regression analyses to compare the effect of methodological variables in the outcomes.

Variables	Accuracy D1 threshold	Accuracy D3 threshold	Intra-examiner reproducibility	Interexaminer reproducibility
Education level				
First-year of course	1	1	1	1
Last-year of course	2.38 (0.23 to 24.21)	3.64 (0.47 to 27.93)	0.21 (-0.15 to 0.57)	0.16 (-0.13 to 0.44)
Clinical experience				
No	1	1	1	—
Yes	0.92 (0.10 to 7.48)	3.64 (0.47 to 27.93)	0.07 (-0.33 to 0.47)	
Learning activities				
Virtual	1	1	1	1
Face-to-face	4.12 (1.89 to 9.01)	0.93 (0.13 to 6.82)	0.18 (-0.15 to 0.52)	0.33 (0.10 to 0.55)
Reference standard				
Clinical consensus	1	1		
Histological	4.44 (1.20 to 16.46)	5.02 (0.88 to 28.70)	—	—
Setting				
Clinical	1	1	1	1
Non-clinical/Laboratorial	0.38 (0.23 to 0.64)	0.17 (0.04 to 0.73)	-0.20 (-0.55 to -0.15)	-0.43 (-0.70 to -0.16)
Photographs	—	—	-0.08 (-0.63 to 0.47)	-0.25 (-0.63 to 0.13)

Table 3. Individual classification considering the quality assessment of studies of diagnostic performance included in systematic reviews (QUADAS-2) tool for accuracy.

Caries severity assessment							
Study	Risk of bias				Applicability Concerns		
	Patient Selection	Index Test	Reference Standard	Flow and Timing	Patient Selection	Index Test	Reference Standard
Laboratorial setting							
Nogueira et al., (2017)[15]	☹	☺	☺	☺	☹	☺	☺
Neuhaus et al., (2015)[21]	☹	☺	☺	☺	☹	☺	☺
Bussaneli et al., (2015)[20]	☹	☺	?	☺	☹	☺	?
Parviainen et al., (2013)[35]	☹	☺	☺	☺	☹	☺	☺
Jablonski-Momeni et al., (2012)[36]	☹	☺	☺	☺	☹	☺	☺
Diniz et al., (2010)[9]	☹	☺	☺	☺	☹	☺	☺
Zandona et al., (2009)[7]	☹	☺	☺	☺	☹	☺	☺
Souza-Zaroni et al., (2006)[23]	☹	?	☺	☺	☹	?	☺
Clinical setting							
Nogueira et al., (2018)[16]	☹	☺	☺	☺	☹	☺	☺
Luz et al., (2015)[18]	☹	☺	☺	☺	☹	☺	☺
Gimenez et al., (2013)[19]	☹	☺	☺	☺	☹	☺	☺
Caries activity assessment							
Study	Risk of bias				Applicability Concerns		
	Patient Selection	Index Test	Reference Standard	Flow and Timing	Patient Selection	Index Test	Reference Standard
Laboratorial setting							
Nogueira et al., (2017)[15]	☹	☺	☹	☹	☹	☺	☹
Clinical setting							
Nogueira et al., (2018)[16]	☹	☺	☹	☹	☹	☺	☹
Gimenez et al., (2013)[19]	☹	☺	☹	☹	☹	☺	☹

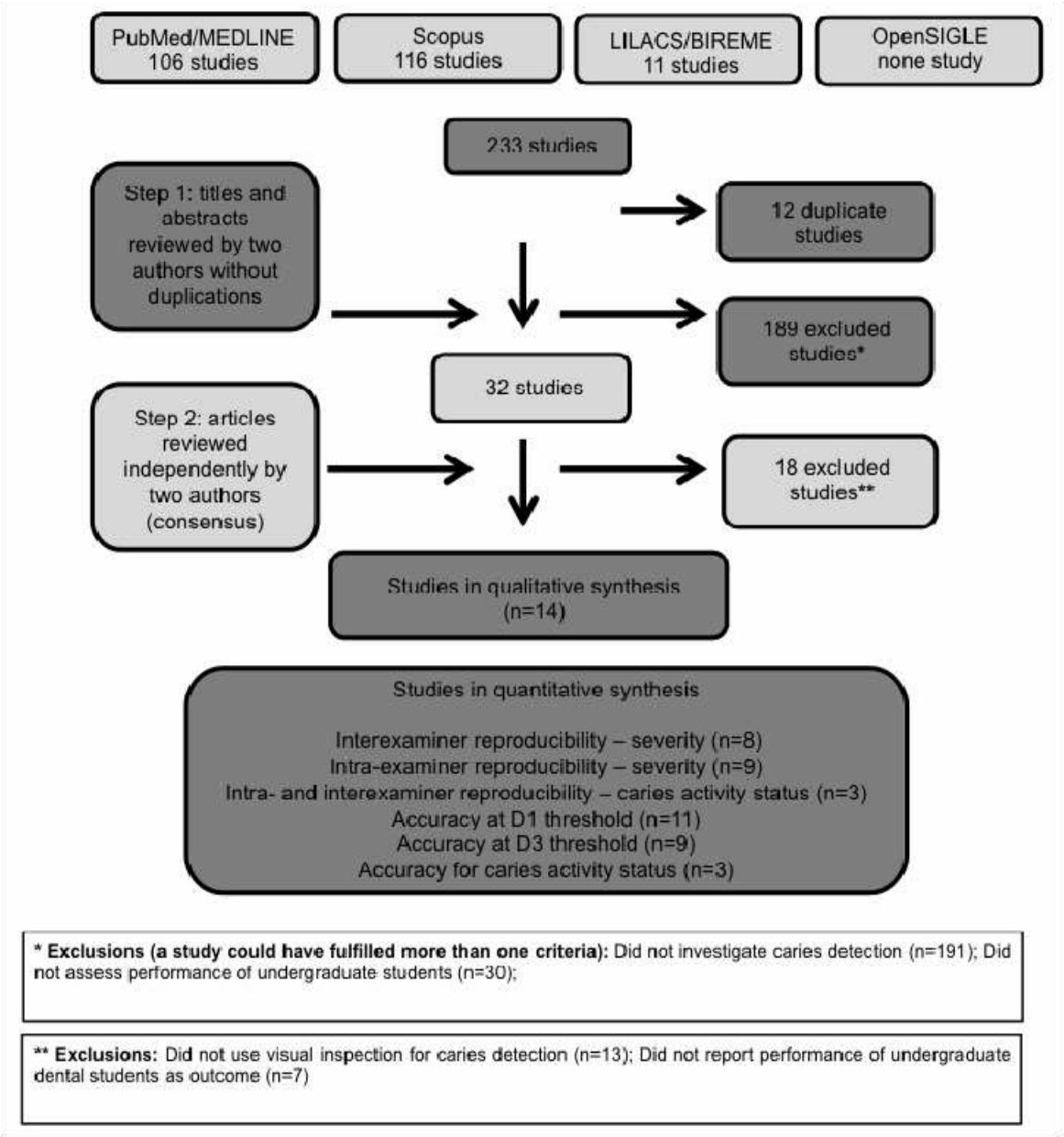

Figure 1. Flow diagram with the information through the phases of study selection.

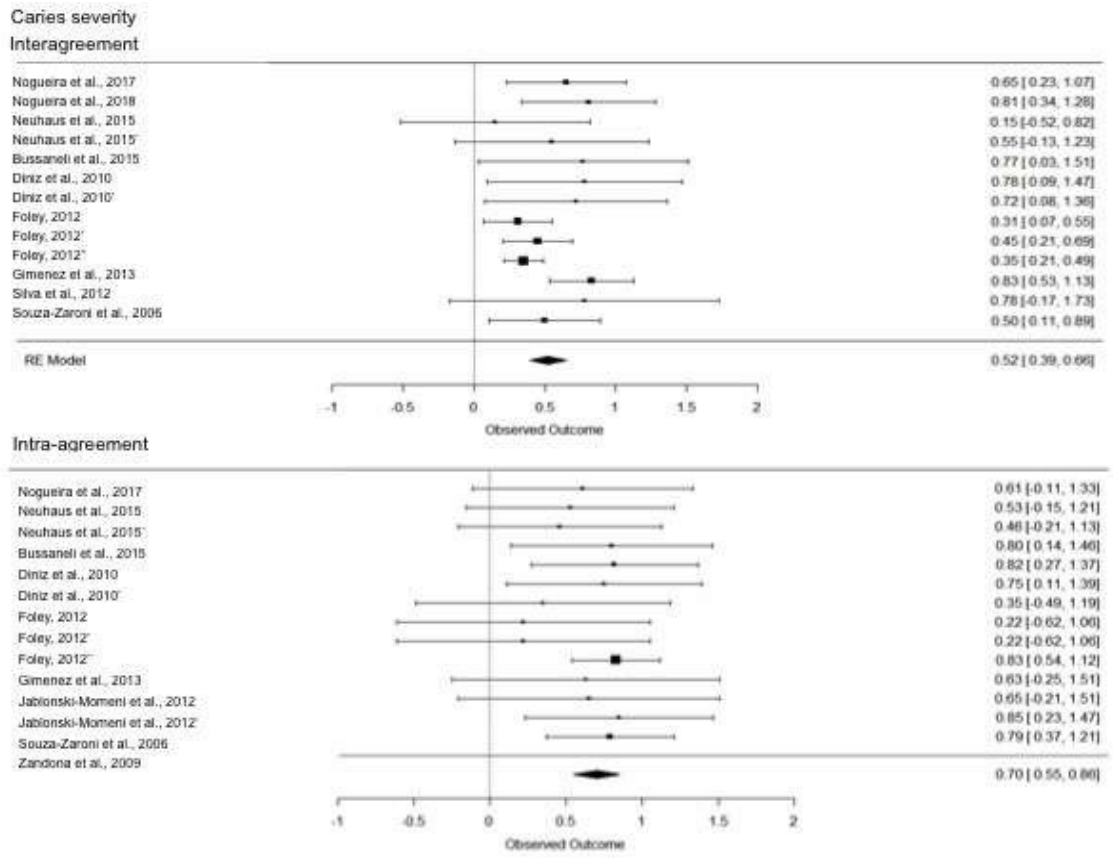

Figure 2. Pooled values of inter and intra-examiner agreement for caries severity.

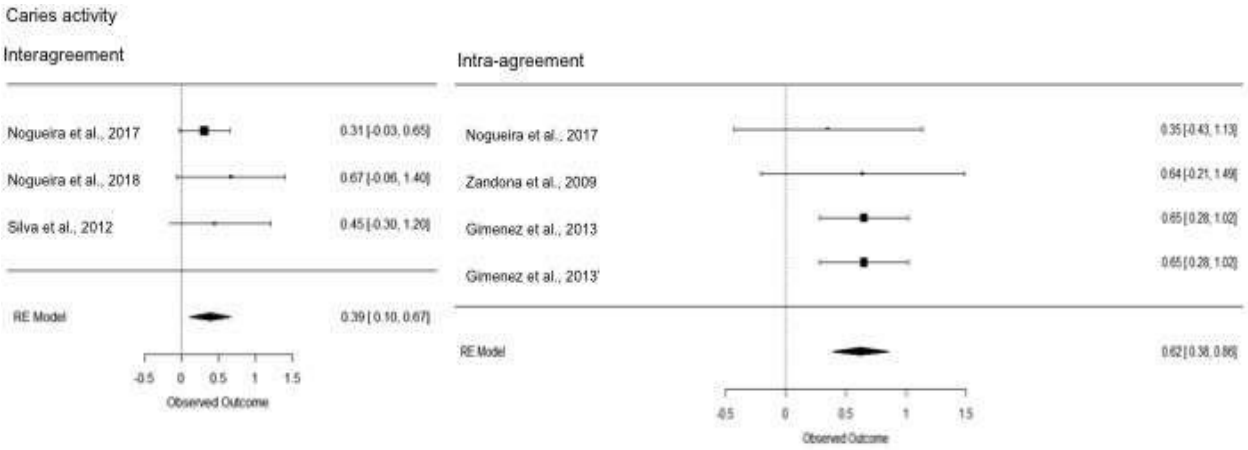

Figure 3. Pooled values of inter and intra-examiner agreement for caries activity.

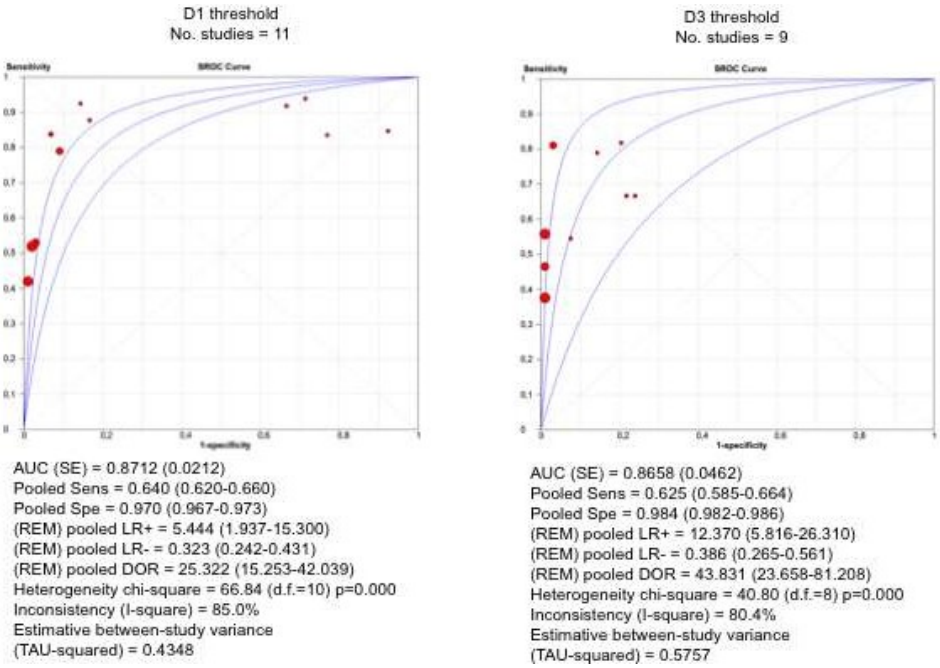

Figure 4. Summary receiver operating characteristic curves and synthesis of the results obtained for accuracy considering caries severity. Each study is represented by a red dot, and the pooled result of all studies by means of the receiver operating characteristic curve is represented by the central curve, while the confidence interval is represented by the upper and lower lines. AUC: area under curve.

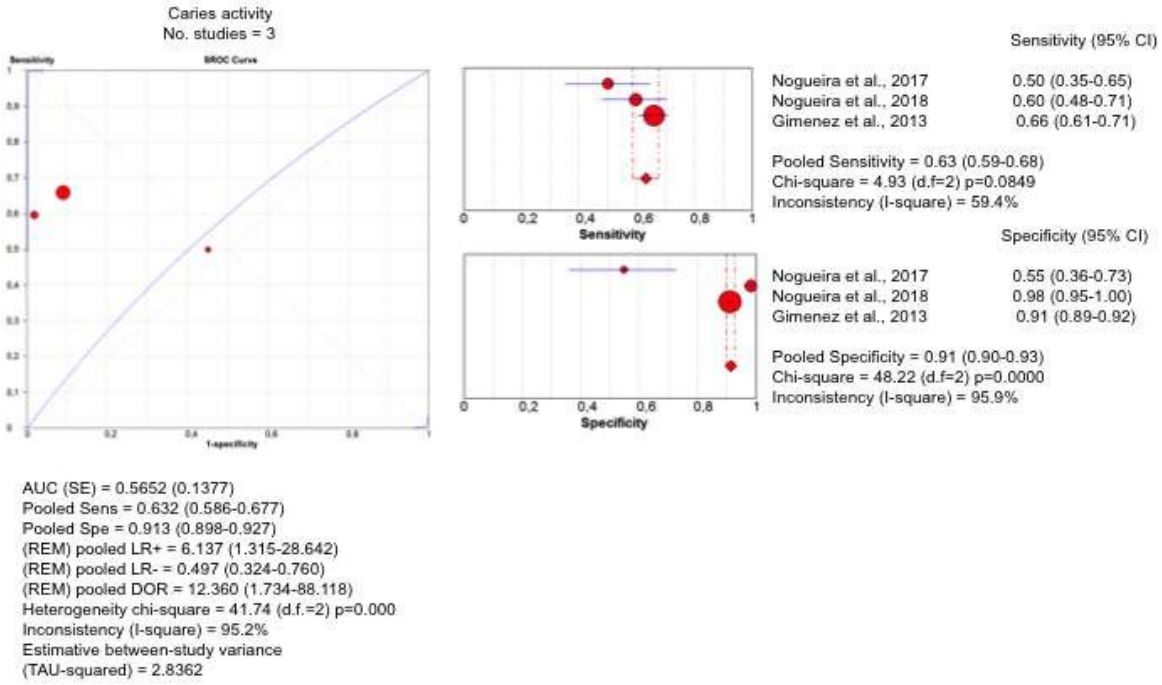

Figure 5. Summary receiver operating characteristic curves and synthesis of the results obtained for accuracy considering activity status of caries lesions.

Legends of the figures

Figure 1. Flow diagram with the information through the phases of study selection.

Figure 2. Pooled values of inter and intra-examiner agreement for caries severity.

Figure 3. Pooled values of inter and intra-examiner agreement for caries activity.

Figure 4. Summary receiver operating characteristic curves and synthesis of the results obtained for accuracy considering caries severity. Each study is represented by a red dot, and the pooled result of all studies by means of the receiver operating characteristic curve is represented by the central curve, while the confidence interval is represented by the upper and lower lines. AUC: area under curve.

Figure 5. Summary receiver operating characteristic curves and synthesis of the results obtained for accuracy considering activity status of caries lesions.

3 CONCLUSÃO

Embora detecção de lesões de cárie seja um dos tópicos mais explorados em termos de ensino de Cariologia, muitas questões ainda permanecem em aberto. Apesar do esforço dos docentes em formar alunos para a prática clínica baseada em evidências; paradoxalmente, pouco se estuda sobre como transmitir todo esse conhecimento para os alunos e, principalmente, se o estudante consegue desenvolver durante a graduação as habilidades diagnósticas necessárias.

Os achados do presente estudo evidenciaram que o desempenho de estudantes de graduação na detecção e avaliação da severidade de lesões de cárie por meio do exame visual parece ser satisfatório, mas pode ser influenciado por diversos fatores metodológicos relacionados à seleção da amostra, ao *setting* do estudo e ao padrão de referência usado. O nível educacional no curso e a experiência clínica prévia não impactaram na acurácia e reprodutibilidade.

Por outro lado, atividades presenciais, envolvendo aula teórica e/ou treinamento com imagens ou dentes extraídos tiveram um efeito positivo no desempenho dos estudantes em relação ao treinamento virtual. Todavia, devido ao pequeno número de estudos, não foi possível averiguar se o treinamento laboratorial é mais efetivo no desenvolvimento de habilidades práticas para avaliação clínica de lesões de cárie do que a aula teórica isolada. Especula-se que a utilização de dentes extraídos seja uma abordagem mais efetiva, uma vez que o uso de imagens pode reduzir a especificidade da inspeção visual porque superestima o tamanho do dente (sítio da lesão). Uma menor especificidade é geralmente associada a maior sensibilidade, o que pode aumentar o número de resultados falso-positivos, acarretando em maior possibilidade de sobretratamento.

Vale ressaltar, que na maioria dos estudos incluídos na revisão sistemática, o índice ICDAS foi utilizado para avaliação das lesões cariosas. À luz das evidências científicas atuais que reforçam o uso de índices a fim de aumentar a acurácia da inspeção visual (GIMENEZ et al., 2015), o uso do ICDAS como uma ferramenta educacional para alunos de graduação deve ser encorajado.

No entanto, a avaliação da atividade de cárie pelos estudantes de graduação precisa ser melhorado. Acredita-se que mais tempo de treinamento e maior experiência clínica são necessários, visto que tal avaliação é passível de

subjetividade mesmo quando da utilização de critérios, como o LAA.

Por fim, há de se considerar que uma pequena amostra de estudantes foi usada maioria dos estudos. Em geral, estudantes mais motivados ou com melhor desempenho acadêmico poderiam ter sido incluídos. Consequentemente, a validade externa é reduzida, dificultando a extrapolação dos resultados. Futuras pesquisas com baixo risco de viés que mensurem o desempenho de uma amostra mais representativa de estudantes de graduação na detecção e avaliação do status das lesões de cárie ainda são necessárias.

REFERÊNCIAS BIBLIOGRÁFICAS

ASSAF, A. V.; ZANIN, L.; MENEGHIM, M. de C.; PEREIRA, A. C.; AMBROSANO, G. M. B. Comparison of reproducibility measurements for calibration of dental caries epidemiological surveys. Cad Saúde Pública 2006; 22(9):1901-1907.

BADER, J.D.; SHUGARS, D.A.; BONITO, A.J. A systematic review of the performance of methods for identifying carious lesions. J Public Health Dent. 2002;62(4):201-213.

BAELUM, V.; HEIDMANN, J.; NYVAD, B. Dental caries paradigms in diagnosis and diagnostic research. Eur J Oral Sci. 2006;114(4):263-277.

BAELUM, V. Caries management: technical solutions to biological problems or evidence-based care? J Oral Rehabil. 2008; 35(2):135-151.

BORNMANN, L.; MUTZ, R.; DANIEL, H.D. A reliability-generalization study of journal peer reviews: a multilevel meta-analysis of inter-rater reliability and its determinants. Rogers S, editor. PLoS One. 2010;5(12):e14331.

BRAGA, M.M.; MENDES, F.M.; EKSTRAND, K.R. Detection Activity Assessment and Diagnosis of Dental Caries Lesions. Dent Clin Noth Am. 2010;54(3):479-493.

BUSSANELI, D. G.; BOLDIERI, T.; DINIZ, M. B.; RIVERA, L. M.; SANTOS-PINTO, L.; CORDEIRO, R. D. E. Influence of professional experience on detection and treatment decision of occlusal caries lesions in primary teeth. Int J Paediatr Dent. 2015;25(6):418-427.

CHEN, T.; MDYUNUS, A.; ALI, W.Z.W.; BAKAR, A. Utilization of Intelligent Tutoring System in mathematics learning. Int J Educ Dev using Inf Commun Technol. 2008;4(4):50-63.

COWPE, J.; PLASSCHAERT, A.; HARZER, W.; VINKKA-PUHAKKA, H.; WALMSLEY, A.D. Profile and competences for the graduating European dentist - update 2009. Eur J Dent Educ. 2010;14(4):193–202.

DINIZ, M.B.; LIMA, L.M.; SANTOS-PINTO, L.; ECKERT, G.J.; ZANDONÁ, A.G.F.; CORDEIRO, R.C.L. Influence of the ICDAS e-learning program for occlusal caries detection on dental students. J Dent Educ. 2010;74(8):862-868.

DOWNER, M.C. Validation of methods used in dental caries diagnosis. Int Dent J. 1989;39(4):241-246.

EKSTRAND, K.R.; GIMENEZ, T.; FERREIRA, F.R.; MENDES, F.M.; BRAGA M.M. The International Caries Detection and Assessment System - ICDAS: A Systematic Review. Caries Res. 2018;52(5):406-419.

EKSTRAND, K.R.; MARTIGNON, S.; RICKETTS, D.J.N.; QVIST, V. Detection and Activity Assessment of Primary Coronal Caries Lesions: A Methodologic Study. Oper Dent. 2007; 32(3):225-235.

EL-DAMANHOURY, H. M.; FAKHRUDDIN, K. S.; AWAD, M. A. Effectiveness of teaching International Caries Detection and Assessment System II and its e-learning program to freshman dental students on occlusal caries detection. Eur J Dent. 2014 8(4):493-497.

FOLEY, J.I. Dental students consistency in applying the ICDAS system within paediatric dentistry. Eur Arch Paediatr Dent. 2012;13(6):319-322.

GIMENEZ, T.; BITTAR, D.; PIOVESAN, C.; GUGLIELMI, C.; FUJIMOTO, K.; MATOS, R.; NOVAES, T.F.; BRAGA, M.M.; MENDES, F.M. Influence of Examiner Experience on Clinical Performance of Visual Inspection in Detecting and Assessing the Activity Status of Caries Lesions. Oper Dent. 2013;38(6):583-590.

GIMENEZ, T.; PIOVESAN, C.; BRAGA, M.M.; RAGGIO, D.P.; DEERY, C.; RICKETTS, D.N.; EKSTRAND, K.R.; MENDES, F.M. Visual Inspection for Caries Detection: A Systematic Review and Meta-analysis. J Dent Res. 2015;94(7):895-904.

GLAS, A.S.; LIJMER, J.G.; PRINS, M.H.; BONSEL, G.J.; BOSSUYT, P.M.M. The diagnostic odds ratio: a single indicator of test performance. J Clin Epidemiol. 2003;56(11):1129-1135.

GOWDA, D.; LAMSTER, I.B. The Diagnostic Process. Dent Clin North Am. 2011;55(1):1–14.

HANLEY, J.A. Standard error of the kappa statistic. Psychol Bull. 1987;102(2):315-321.

JABLONSKI-MOMENI, A.; BUSCHE, J.F.; STRUWE, C.; LANGE, J.; HEINZEL-GUTENBRUNNER, M.; FRANKENBERGER, R.; PIEPER, K. Use of the international caries detection and assessment system two-digit coding method by predoctoral dental students at Philipps University of Marburg, Germany. J Dent Educ. 2012;76(12):1657-1666.

LARA, J. S.; BRAGA, M. M.; SHITSUKA, C.; WEN, C. L.; HADDAD, A. E. Dental students' and lecturers' perception of the degree of difficulty of caries detection associated learning topics in Brazil. J Educ Eval Health Prof. 2015.

LIBERATI, A.; ALTMAN, D.G.; TETZLAFF, J.; MULROW, C.; GØTZSCHE, P.C.; IOANNIDIS, J.P.A.; CLARKE, M.; DEVEREAUX, P.J.; KLEIJNEN, J.; MOHER, D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med. 2009;6(7):e1000100.

LUZ, P. B.; STRINGHINI, C. H.; OTTO, B. R.; PORT, A. L.; ZALESKI, V.; OLIVEIRA, R. S.; et al. Performance of undergraduate dental students on ICDAS clinical caries detection after different learning strategies. Eur J Dent Educ. 2015;19(4):235-241.

NEUHAUS, K.W.; JOST, F.; PERRIN, P.; LUSSI, A. Impact of different magni fi cation levels on visual caries detection with ICDAS. J Dent. 2015;43(12):1559-1564.

NOGUEIRA, V.K.C.; BUSSANELI, D.G.; RESTREPO, M.R.; SPIN-NETO, R.; DOS SANTOS-PINTO, L.A.M.; BOLDIERI, T. CORDEIRO, R.C.L. Caries treatment decisions among undergraduate and postgraduate students supported by visual detection systems. Int J Paediatr Dent. 2018;28(1):92-101.

NOGUEIRA, V.K.C.; BUSSANELI, D.G.; TAGLIAFERRO, E.P.D.S.; SPIN-NETO, R.; ESCOBAR, A.; CORDEIRO, R.D.C.L. Examiner's experience and the outcome interpretation of ICDAS and Nyvad's system – a prospective *in vitro* study. Acta Odontol Scand. 2017;75(3):186-190.

NYVAD, B. Diagnosis versus detection of caries. Caries Res. 2004;38(3):192-198.

NYVAD, B.; BAELUM, V. Nyvad Criteria for Caries Lesion Activity and Severity Assessment: A Validated Approach for Clinical Management and Research. Caries Res. 2018;52(5):397-405.

PARVIAINEN, H.; VÄHÄNIKKILÄ, H.; LAITALA, M-L.; TJÄDERHANE, L.; ANTTONEN, V. Evaluating performance of dental caries detection methods among third-year dental students. BMC Oral Health. 2013; 13(1):70.

PITTS, N.B. Modern Concepts of Caries Measurement. J Dent Res. 2004;83:C43-C47.

PITTS, N.B.; MELO, P.; MARTIGNON, S.; EKSTRAND, K.; ISMAIL, A. Caries risk assessment, diagnosis and synthesis in the context of a European Core Curriculum in Cariology. Eur J Dent Educ. 2011;15(Suppl 1):23-31.

SCHULTE, A.G.; BUCHALLA, W.; HUYSMANS, M.C.; AMAECHI, B.T.; SAMPAIO, F.; VOUGIOUKLAKIS, G.; PITTS, N.B. A survey on education in cariology for undergraduate dental students in Europe. Eur J Dent Educ. 2011;15(Suppl 1):3-8.

SCHULTE, A.G.; PITTS, N.B.; HUYSMANS, M.C.D.N.J.M.; SPLIETH, C.; BUCHALLA W. European Core Curriculum in Cariology for Undergraduate Dental Students. Caries Res. 2011;45:336-345.

SILVA, P.F.; FORTE, F.D.S.; CHAVES, A.M.B.P.; FARIAS, I.A.P.; CASTRO, K.S. Reproducibility of caries diagnosis in permanent teeth according to WHO, ICDAS-II and Nyvad criteria. Brazilian J Oral Sci. 2012;11(1):25-29.

SOUZA-ZARONI, W.C.; CICCONE, J.C.; SOUZA-GABRIEL, A.E.; RAMOS, R.P.; CORONA, S.A.M.; PALMA-DIBB, R.G. Validity and reproducibility of different combinations of methods for occlusal caries detection: An in vitro comparison. Caries Res. 2006;40(3):194–201.

WHITING, P.F.; RUTJES, A.W.S.; WESTWOOD, M.E.; MALLETT, S.; DEEKS, J.J.; REITSMA, J.B. et al. QUADAS-2: A Revised Tool for the Quality Assessment of Diagnostic Accuracy Studies. Ann Intern Med. 2011;155(8):529-536.

ZANDONÁ, A. G.; AL-SHIHA, S.; EGGERTSSON, H.; ECKERT, G. Student versus faculty performance using a new visual criteria for the detection of caries on occlusal surfaces: an in vitro examination with histological validation. Oper Dent. 2009;34(5):598-604.

ANEXO A – Normas do periódico *Journal of Dental Education*

Journal of Dental Education
INFORMATION FOR AUTHORS

The *Journal of Dental Education* is a peer-reviewed monthly journal that publishes a wide variety of scientific and educational research in dental, allied dental, and postdoctoral dental education. Published continuously since 1936 and internationally recognized as a premier journal for academic dentistry, the *JDE* publishes articles on such topics as curriculum reform, research methods, innovative educational and assessment methodologies, faculty development, community-based dental education, student recruitment and admissions, professional and educational ethics, dental education around the world, and systematic reviews of clinical trials regarding oral, dental, and craniofacial diseases and disorders. The *JDE* is one of the top scholarly journals publishing the most important work in oral health education today and celebrated its seventy-fifth anniversary in 2011.

The Editor, Dr. Nadeem Karimbux, welcomes submissions that report research and address issues in the following areas: 1) Critical Issues in Dental Education; 2) Milieu in Dental School and Practice; 3) Educational Methodologies; 4) Evidence-Based Dentistry; 5) Faculty Development; 6) Transfer of Advances in Sciences into Dental Education; 7) International Dental Education; 8) From the Students' Corner; and 9) Perspectives. Authors from outside North America are welcome to submit articles in any of these areas, as well as the International section, which is dedicated to work primarily relevant to the author's own country. Students are also welcome to submit articles in any of the areas and are especially encouraged to submit to the From the Students' Corner section, which is open to an extremely wide range of subject matter and style. Perspectives articles are opinion- rather than research-oriented, though they may include data to support their arguments. Authors who wish to submit manuscripts in areas beyond these should check with the Editor first.

All manuscripts must be written in English and submitted exclusively to the *Journal of Dental Education* to be considered for publication.

Preparing Manuscripts for Submission

The *JDE* considers only manuscripts submitted electronically, prepared in MS Word. Authors are urged to follow the "Uniform Requirements for Manuscripts Submitted to Biomedical Journals." These requirements, developed by the International Committee of Medical Journal Editors and now in their fifth edition (1997), can be found in the *New England Journal of Medicine* 1997;336:309-15 and on that journal's website.

The following summarizes these requirements as well as specific JDE procedures. Note that these requirements pertain specifically to the initial submission of manuscripts. When an article has been or is close to being accepted, authors should follow the "Production Guide for *JDE* authors" (available on the ScholarOne website) in preparing the final version of the article.

Document Preparation. Create the document on pages with margins of at least 1 inch (25 mm). Use double-spacing throughout, including title page, abstract, text, acknowledgments, references, tables, and legends for illustrations, and number pages consecutively. Begin each of the following sections on separate pages: title page, abstract and key words, text, acknowledgments, references, individual tables, and legends. Do not embed tables and figures

in the body of the text, but place them after the references. If any illustrations are large files, submit them as separate documents.

Title Page. The title page should carry 1) the title, which should be concise but descriptive; 2) first name, middle initial, and last name of each author, with highest academic degrees; 3) each author or coauthor's job title, department, and institution; 4) disclaimers if any; 5) name, address, phone, fax, and email of author responsible for correspondence about the article and requests for reprints; and 6) support or sources in the form of grants, equipment, drugs, etc. See published articles for examples.

Abstract and Key Words. The second page should carry the title and an abstract of no more than 150-200 words. In one paragraph, the abstract should state the purposes of the study or program, basic procedures, main findings, and principal conclusions. Neither references nor subheads should be used in the abstract. Below the abstract, provide three to ten key words or phrases that will assist indexers in cross-indexing the article and that will be published with the abstract. Use terms from the Medical Subject Headings listed in *Index Medicus*.

Text. Follow American rather than British English spelling and punctuation style. The body of the manuscript should be divided into sections preceded by appropriate subheads. Major subheads should be typed in capital letters at the left-hand margin. Secondary subheads should appear at the left-hand margin and be typed in upper and lower case and put in bold face. Tertiary subheads should be typed in upper and lower case and be underlined.

References. Number references consecutively in the order in which they are first mentioned in the text; each source has one number, so be careful not to repeat sources in the reference list. Identify references by Arabic numerals, and place them as superscript numerals within or at the end of the sentence. Do <u>not</u> enclose the numerals in parentheses, and be sure to follow American rather than British or European style conventions (e.g., the reference number follows rather than precedes punctuation marks, such as commas and periods). Two important reminders: 1) references should <u>not</u> be linked to their numbers as footnotes or endnotes; and 2) references to tables and figures should appear as a source note with the table/figure, not numbered consecutively with the references for the article.

Follow the style of these general examples, which are based on the formats used in *Index Medicus*. Titles of journals should be abbreviated according to the *Index Medicus* style. If there are more than six authors, list the first six and use et al.

Book

1. Avery JK. Essentials of oral histology and embryology: a clinical approach. 2nd ed. St. Louis: Mosby, 2000.

Chapter in an Edited Volume

2. Inglehart MR, Filstrup SL, Wandera A. Oral health and quality of life in children. In: Inglehart MR, Bragramian RA, eds. Oral health-related quality of life. Chicago: Quintessence Publishing Co., 2002:79-88.

Article in a Journal

3. Seale NS, Casamassimo PS. U.S. predoctoral education in pediatric dentistry: its impact on access to dental care. J Dent Educ 2003;67(1):23-9.

Report

4. Commission on Dental Accreditation. Accreditation standards for dental education programs. Chicago: American Dental Association, 2010.

Tables. All tables must have a title and be in a column format. Arrange column headings so that their relation to the data is clear. Indicate explanatory notes to items in the table with reference marks (note that asterisks should be used only with p-values). Cite each table in the text in the order in which it is to appear; do not include directions such as "Place Table 1 here." Identify tables with Arabic numerals (e.g., Table 1). See the References section regarding source notes.

Illustrations. Illustrations should not exceed 8½ x 11 inches, and all lettering should be at least 1½ mm high. Cite each figure in the text in the order in which it is to appear (e.g., Figure 1); do not include directions such as "Place Figure 1 here." See the References section regarding source notes. If your article is accepted for publication, we may request illustrations in higher resolution than those you've submitted.

Human Subjects. It is the author's responsibility to obtain approval or exempt status from his or her institution's Institutional Review Board for studies involving human subjects; this approval or exempt status should be mentioned in the article. Failure to meet these requirements is likely to place the manuscript in jeopardy and lead to a rejection.

Permissions. Any aspect of the article that is not the author's original work (e.g., figures or tables from other publications) must be fully credited to the original publication. It is the author's responsibility to acquire permission to reprint the material and pay any fees. Evidence of required permissions must be in the author's hands before the article can be published. Additional information is provided in the "Production Guide for JDE Authors."

Submission and Production Procedures

Submissions should be made via the ScholarOne system, following these steps:

1. Launch your web browser, and go to the *JDE*'s submission homepage at http://mc.manuscriptcentral.com/jdentaled.
2. Log-in, or click the "Register here" option if you are a first-time user of ScholarOne Manuscripts. Follow the instructions to create a new account. If you have forgotten your log-in details, go to "Password Help" on the journal's ScholarOne Manuscripts' homepage and enter your email address. You will be sent instructions on how to reset your password.
3. After logging in, select "Author Center." Click the "Submit a Manuscript" link. Enter data and answer questions as prompted. Click on the "Next" button on each screen to save your work and advance to the next screen.
4. To upload your files, click on the "Browse" button, locate the file on your computer, and select the appropriate designation. Click the "Upload" button when all files have been selected. Please review your submission (in both PDF and HTML formats) before sending to the Editor. Click the Submit button.

Review Process. Manuscripts will be peer-reviewed by individuals, selected by the Editor or Associate Editor, who have expertise and experience pertinent to the topic of the article. The journal follows a blind peer review process. The Editor and/or Associate Editor also review all manuscripts. The review process can take up to four months.

Preparing the Final Manuscript. If the manuscript is accepted or provisionally accepted, it will be returned to the author with the reviewers' comments for the author's approval, responses, and revisions. At that time, the author should download the "Production Guide for *JDE* Authors" from the ScholarOne website and follow it in preparing the final version of the article. After the author has made the changes, the manuscript is returned for final review to the Editor. If the Editor finds it acceptable, he notifies the author and assigns it to an issue. Managing Editor Lynn Page Whittaker copyedits it and prepares it for publication. Currently, the time from acceptance to publication is approximately eight to ten months.

Agreement to Publish. On acceptance or provisional acceptance of the manuscript for publication, the author will be asked to sign a publication agreement, which must be signed and submitted before the article is published. This form is a legal document specifying that the article is original and that the author holds all rights in it and grants the journal the exclusive first serial rights to it, for both paper and online publication. If the article is coauthored, all authors must sign the agreement.

Page Proof Review. Corresponding authors will receive page proofs of their articles by email from the Managing Editor, who also reads the proofs. Authors will have two to three business days to review their proofs and return them.

Reprints and Permissions. Authors are given the opportunity to order reprints of their articles and are urged to do so at the time the issue is printed for the most timely and efficient service; however, reprint orders will be accepted at any time after the issue is published. The price of reprints varies with the page count of the article and the quantity of reprints ordered. The Managing Editor sends detailed information and an order form to the corresponding author with the article proofs. A copy of an individual article may also be acquired online, whether by the authors or other readers, by visiting www.jdentaled.org. The *JDE* permits photocopying of articles for the noncommercial purpose of educational and scientific advancement.

Key Contact Information

General Questions (not for submission of manuscripts; see above). Contact Dr. Nadeem Karimbux, Editor, Journal of Dental Education, Tufts University School of Dental Medicine One Kneeland St. DHS-15, Boston, MA 02111; nadeem.karimbux@tufts.edu.

Proofs and Production. Return proofs and direct any questions concerning publication to Lynn Page Whittaker, Managing Editor, Journal of Dental Education, 127 Autumnwood Avenue, Athens, GA 30606; whittakerl@adea.org.

Reprints and Copyright Permissions. Address correspondence relating to copyright and other business matters to Christopher Daniels, ADEA, 1400 K Street, NW, Suite 1100, Washington, DC 20005; 202-289-7201 phone; 202-289-7204 fax; danielsc@adea.org.

APÊNDICE A – Material suplementar

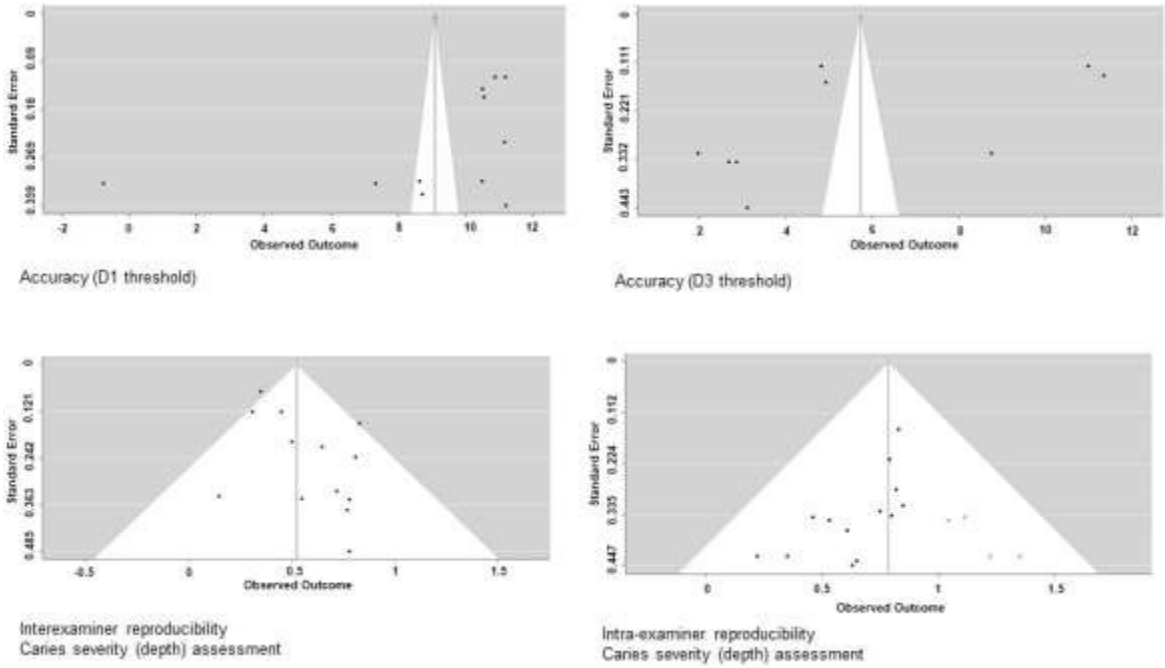

Figura S1 – Avaliação de viés de publicação.