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# Methods dentists use to diagnose primary caries lesions prior to restorative treatment: Findings from The Dental PBRN

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ABSTRACT

*Objective:* To (1) quantify the diagnostic techniques used by Dental Practice-Based Research Network (DPBRN) dentists before they decide to treat primary caries lesions surgically and (2) examine whether certain dentist, practice, and patient characteristics are associated with their use.

*Methods:* A total of 228 DPBRN dentists recorded information on 5676 consecutive restorations inserted due to primary caries lesions on 3751 patients. Practitioner-investigators placed a mean of 24.9 (SD = 12.4) restorations. Lesions were categorised as posterior proximal, anterior proximal, posterior occlusal, posterior smooth, or anterior smooth. Techniques used to diagnose the lesion were categorised as clinical assessment, radiographs, and/or optical. Statistical analysis utilised generalised mixed-model ANOVA to account for the hierarchical structure of the data.

*Results:* By lesion category, the diagnostic technique combinations used most frequently were clinical assessment plus radiographs for posterior proximal (47%), clinical assessment for anterior proximal (51%), clinical assessment for posterior occlusal (46%), clinical assessment for posterior smooth (77%), and clinical assessment for anterior smooth (80%). Diagnostic technique was significantly associated with lesion category after adjusting for clustering in dentists ( $p < 0.0001$).

*Conclusion:* These results – obtained during actual clinical procedures rather than from questionnaire-based hypothetical scenarios – quantified the diagnostic techniques most commonly used during the actual delivery of routine restorative care. Diagnostic technique varied by lesion category and with certain practice and patient characteristics.



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## 1. Introduction

Detection of caries lesions is crucial to their prevention and treatment.[1] The ideal method of detection accurately measures the depth of the caries process,[2] which is important in monitoring progression of active lesions and in making clinical decisions. Our current understanding[3] of the caries process provides clinicians with treatment options to arrest or remineralise early lesions. If the lesion has progressed to cavitation, it is not amenable to remineralisation and requires a restoration.[4] However, the widespread use and availability of fluoride has dramatically slowed the progression of carious lesions[5] such that dentists typically detect caries at an earlier stage. In view of these changes, accurate caries detection has a critical impact on treatment decisions; incorrect diagnosis may result in incorrect treatment decisions, particularly with respect to operative intervention.

Variation amongst dentists in the identification and depth estimation of caries lesions is well-known,[6–9] mostly from studies of ''cases'' prepared by investigators. There have been few assessments of the detection techniques being used by dentists in clinical practice.[10–14] To learn more, we need to examine how clinicians identify lesions in their practices.

This study is a component of a broader research programme being undertaken by ''The Dental Practice-Based Research Network'' (DPBRN, www.DPBRN.org) to investigate how dentists diagnose and treat dental caries.[15–19] DPBRN is a consortium of dental practices with a broad representation of practice types and treatment philosophies that conducts research across geographically dispersed regions. The objectives of this study are (1) to quantify the diagnostic techniques used by DPBRN practitioner-investigators before they decide to treat primary caries lesions surgically, and (2) to examine whether certain dentist, practice, and patient characteristics are associated with the use of these techniques.

## 2. Materials and methods

### 2.1. Selection and recruitment process

Practitioner-investigators from DPBRN who perform restorative dentistry in their practices were enrolled in this study. DPBRN comprises five regions: Alabama/Mississippi (AL/MS), Florida/Georgia (FL/GA), Minnesota dentists employed by HealthPartners Dental Group or practicing in the community (MN), Permanente Dental Associates in cooperation with Kaiser Permanente's Center for Health Research (PDA), and Denmark, Norway, and Sweden (SK).[15] Practitioner-investigators in DPBRN were recruited into the network through continuing education courses and mass mailings to licensed dentists from the participating regions. As part of enrollment in DPBRN, all practitioner-investigators complete a DPBRN Enrollment Questionnaire about themselves and their practice characteristics. As part of eligibility for this particular study, all dentists completed (1) the Enrollment Questionnaire, (2) an Assessment of Caries Diagnosis and Caries Treatment Questionnaire, (3) training in human subjects protection, and (4) a training session with a DPBRN staff[20] regional coordinator assigned to their practice. This training session discussed in detail the study protocol, data collection forms, and related details. Additional requirements varied by DPBRN region and are described elsewhere.[21] These questionnaires are publicly available on the DPBRN Supplement page.[22]

### 2.2. Study design

This cross-sectional study used a consecutive patient/restoration recruitment design. Once the study was started in a practice, every patient scheduled to have a restoration on a previously unrestored permanent tooth surface was asked to participate until 50 patients had been enrolled or a certain date had passed. If patients had multiple appointments during the study period, data were collected only at the first appointment. To broaden enrollment, we limited the number of eligible restorations to four during the patient's first appointment in the study period. A consecutive patient/restoration log form was used to record information on eligible restorations regardless of whether the patient participated in the study. All of the data collection forms used for this study is available on the DPBRN Supplement page (www.dentalpbrn.org/users/publications/supplement.aspx). The survey was pilot-tested to assess the feasibility and comprehension of each questionnaire item.[23]

We collected data for: (a) patient race, Hispanic/Latino ethnicity, sex, and age; (b) tooth number, surface, and primary reason for placement of the restoration (i.e., primary caries or non-carious defect); and (c) techniques used to diagnose the primary caries (i.e., probing, radiographs, transillumination, or optical technique such as DIAGNOdent). This study also collected data on preoperative depth, postoperative depth, and restorative materials placed. The latter results are not presented here; we limited our analyses to carious lesions involving only one surface. We considered multisurface categories, but the number of lesions in each category was small, limiting our ability to draw meaningful conclusions.

### 2.3. Dentist-level and practice-level variables

Dentist-level variables were available from the DPBRN Enrollment Questionnaire. In addition to DPBRN region, DPBRN dentists can also be characterised by type of practice (i.e., solo or small group private practice [SGP], large group practice [LGP], or public health practice (PHP). SGPs were defined as having no more than three dentists. LGPs were defined as having four or more dentists. PHPs were defined as receiving most of their funding from public sources. In the AL/MS region, 98% of practitioner-investigators were in SGPs, and 2% were in PHPs. In the FL/GA region, 97% were in SGPs, and 3% were in PHPs. In the MN region, 90% were in LGPs, and 10% were in SGPs. In the PDA region, all were in LGPs. In the SK region, 64% were in SGPs, and 36% were in PHPs. The dentist's year of graduation from dental school, gender, and ethnicity were also available. Dentists were given several choices to describe their workload during the past year.

### 2.4. Patient-level variables

For each enrolled patient, data were collected about the patient's gender, age, race, Hispanic or Latino ethnicity, and any dental insurance or third-party coverage.

### 2.5. *Statistical analysis*

Our primary statistical analytic approach used generalised linear models (GLM) implemented with generalised estimating equations (GEE) in SAS® PROC GENMOD software to conduct analysis of variance (ANOVA) and logistic regression analysis, accounting for correlations amongst observations due to the hierarchical structure of the data/clustering. A generalised estimating equations approach to logistic regression was used to model the associations between use of diagnostic technique and dentist-, practice-, and patient-level characteristics whilst simultaneously accounting for within-dentist, within-practice, and within-patient clustering. This clustering is due to the fact that dentists/practices enrolled numerous patients from the same practice (within-dentist clustering), and patients could have had as many as four restorations during the study (within-patient clustering). Diagnostic method use showed a median intra-class correlation coefficient (ICC) of 0.22 for clustering by dentist and practice, and 0.54 for clustering by patient within dentist and practice; accounting for the effect of clustering was essential to the validity of the statistical models. Maximum-likelihood estimates of ICCs were obtained from the GEE working correlation matrices. Ordinarily, bivariate cross-tabulations done as in Tables 2 and 3 would be tested for statistical significance using $\chi^2$ tests and Mantel-Haenszel $\chi^2$ trend tests. However, this was not appropriate in this context because of the within-class clustering. Therefore, statistical tests in Table 4 were done using GEE-based logistic regressions to account for the effect of this clustering.

Lesions were classified into five categories on the basis of the surfaces identified as involved in the restoration (i.e., posterior proximal, anterior proximal, posterior occlusal, posterior smooth surface, and anterior smooth surface). Frequencies of use of each of the techniques were tabulated by surface classification and region for all restorations. Because more than one technique could be specified, and more than a single surface could be included in a single restoration, these counts are not mutually exclusive. GEE-based ANOVA was used to compare rates of use of the diagnostic techniques amongst regions and surface classifications. GEE logistic regression was conducted to identify predictors of use of each of the diagnostic techniques. These analyses were restricted to restorations classified into a single surface category. Modelling was conducted separately for each of the diagnostic techniques.

Model selection was conducted within two blocks of potential predictors, representing (1) practitioner- and practice-level variables and (2) patient-level variables. Practitioner-level variables included region, gender, years since graduation from dental school (<5, 5–15, 15–20, >20), type of practice (SGP, LGP, or PHP), and whether caries risk assessment is routinely conducted (no or no response; yes, no form used or not known if form was used; yes, using form). Patient-level variables considered were age, gender, race (white, black, American Indian/Alaska native, Asian, native Hawaiian/other Pacific islander, other), ethnicity (Hispanic/Latino, not), and whether the patient had dental insurance. Within each block, separate analyses were conducted for each potential predictor variable. Variables showing significant association at $p < 0.10$ with use of a technique were then included in a multiple logistic regression model. Variables that were significant at $p < 0.10$ in either of the block-level multivariable models were included in a final predictive model for the respective diagnostic technique to avoid excluding variables that might become more significant in the multivariable model.

## 3. Results

Ninety-five percentage of eligible consecutive patients enrolled in the study. Table 1 shows the percentage of use of the different methods of diagnosis, alone or in combination with the other techniques, by lesion location. Diagnostic technique was significantly associated with lesion location after adjusting for clustering in dentists ($p < 0.0001$). Radiographs plus clinical assessment (47%) and radiographs alone (40%) were used most commonly to detect posterior proximal caries. Clinical assessment (51%) and clinical assessment plus radiographs (29%) were the most common detection method for anterior proximal caries. Clinical assessment only (46%) and clinical assessment plus radiographs (41%) were the most common approaches for occlusal surfaces. Clinical assessment only was used by the large majority of dentists to detect caries on posterior (77%) and anterior smooth surfaces (80%).

Dentist and practice characteristics potentially associated with the use of each diagnostic technique were first analysed in a univariate model (Table 2). Variables associated at $p < 0.10$ were included in the final model. Thus, practice type, use of caries risk assessment, and region were included in the final model for clinical assessment; practice type and region in the model for radiographs; and use of risk assessment and region in the model for transillumination or optical technique.

**Table 1 – Diagnostic techniques used overall and by lesion location (limited to restorations that were done because of a caries lesion on one surface only).**

| | Posterior proximal | Anterior proximal | Posterior occlusal | Posterior smooth | Anterior smooth |
|---|---|---|---|---|---|
| Clinical assessment only | 138 (8.8%) | 225 (50.5%) | 993 (46.3%) | 747 (76.8%) | 295 (79.5%) |
| Radiographs only | 637 (40.4%) | 35 (7.9%) | 74 (3.5%) | 12 (1.2%) | 11 (3.0%) |
| Optical only | 2 (.01%) | 11 (2.5%) | 19 (0.9%) | 2 (0.2%) | 1 (0.3%) |
| Clinical assessment + radiographs | 740 (47.0%) | 128 (28.7%) | 886 (41.3%) | 194 (19.9%) | 57 (15.4%) |
| Clinical assessment + optical | 4 (0.3%) | 26 (5.8%) | 103 (4.8%) | 10 (1.0%) | 6 (1.6%) |
| Radiographs + optical | 27 (1.7%) | 9 (2.0%) | 15 (0.7%) | 7 (0.7%) | 0 (0.0%) |
| All three | 28 (1.8%) | 12 (2.7%) | 57 (2.7%) | 1 (0.1%) | 1 (0.3%) |
| Total | 1576 (100%) | 446 (100%) | 2147 (100%) | 993 (100%) | 371 (100%) |

**Table 2 – Association ($p$ value) of dentist and practice characteristics with use of diagnostic technique in one variable models.**

| Characteristic | $p$ value | | |
|---|---|---|---|
| | Clinical assessment | Radiograph | Transillumination or optical technique |
| Years since graduation | 0.2307 | 0.4687 | 0.1304 |
| Gender of dentist | 0.1135 | 0.2984 | 0.9965 |
| Race/ethnicity of dentist | 0.5893 | 0.5127 | Note |
| Practice type (solo, group, public) | 0.0187 | 0.0007 | 0.1358 |
| Caries risk assessment | 0.0531 | 0.1125 | 0.0159 |
| Region | 0.0017 | 0.0010 | 0.0337 |

Note: Estimation algorithm failed. Dentist race distribution is sparse (88.8% white) and relatively small number (341) of uses of optical technique (307 of which were done by white dentists).

**Table 3 – Association ($p$ value) of patient characteristics with use of diagnostic technique in one variable models.**

| Characteristic | $p$ value | | |
|---|---|---|---|
| | Clinical assessment | Radiograph | Transillumination or optical technique |
| Age | 0.0529 | <0.0001 | 0.5783 |
| Gender | 0.9231 | 0.7822 | 0.0633 |
| Race | 0.8150 | 0.3633 | 0.6636 |
| Ethnicity | 0.0022 | 0.2707 | 0.9742 |
| Insurance | 0.8411 | 0.1094 | 0.3852 |

Patient characteristics that were evaluated for association with the use of a diagnostic technique are presented in Table 3. For clinical assessment, patient age and ethnicity were included in the final model; for radiographs, patient age and insurance coverage were included; and for transillumination or optical technique, patient gender was included.

Patient, dentist, and practice characteristics included in the multiple logistic regression model are presented in Table 4. Regional differences were detected in the use of clinical assessment ( $p = 0.0021$) and radiographs ($p = 0.0007$). The AL/MS and FL/GA regions rely more on clinical assessment and less on radiographs than other regions. We also saw an association of region ($p = 0.0189$) and use of transillumination or optical technique. The overall use of optical technique was low (used to detect 371 lesions), and the results are difficult to summarise because of differences in cluster size.

Patient variables associated with the use of diagnostic technique include age ($p < 0.0001$, for radiograph), ethnicity ($p = 0.0023$, for clinical assessment), and dental insurance ($p = 0.0449$, for radiograph). Older patients are less likely to receive radiographs. Clinical assessment was listed for 91.5% of restorations in Hispanic patients vs. 81.9% of restorations in non-Hispanic patients. Patients with dental insurance are less likely to receive radiographs.

## 4. Discussion

These results further illuminate the diagnostic techniques used by dentists in daily practice to detect initial caries on a previously unrestored surface. They also provide insight into patient and provider characteristics that may influence the use of these techniques. Regional differences in the application of the clinical assessment would suggest differences in training and accepted standards of care. We need to be careful in drawing conclusions about the use of transillumination or

**Table 4 – Association of dentist, practice, and patient characteristics with use of diagnostic technique in final models (only statistically significant $p$ values are provided).**

| Characteristic | Clinical assessment | Radiograph | Transillumination or optical technique |
|---|---|---|---|
| Years since graduation from dental school | | | |
| Gender of dentist | | | |
| Practice type (SGP, LGP, PHP) | | | |
| Dentist uses caries risk assessment | | | |
| Region | 0.0021 | 0.0007 | 0.0189 |
| Patient age | | <0.0001 | |
| Patient gender | | | 0.0671 |
| Patient race | | | |
| Patient ethnicity | 0.0023 | | |
| Whether patient has dental insurance | | 0.0449 | |

LGP: large group practice; PHP: public health practice; SGP: small group practice.

optical techniques, because they are used infrequently and usually in combination with other techniques.

Use of radiographs is related to DPBRN region, age of the patient, and dental insurance benefits. It is possible that older patients have a longer dental history for the dentist to consider when deciding if a radiograph is needed to detect caries in areas not observed visually. Dental insurance determines the cost to the patient for radiographs; the counterintuitive observation that patients with dental insurance are less likely to receive radiographs suggests that benefit limitations common to dental insurance policies may influence provider and patient decisions regarding radiographs. The regional differences might be related to teaching and peer norms regarding the prescribing of radiographs.

Clinical assessments and radiographs continue to be the primary caries detection methods employed by dentists in daily practice. Despite the marketing of diagnostic tools such as DIAGNOdent, they are used at very low rates by dentists enrolled in The DPBRN. As new diagnostic techniques become available in the future, practice-based research networks will afford us the opportunity to examine their adoption in daily practice. A recent systematic review of current evidence presented in the literature concluded that utilisation of a combination of visual-tactile and radiographic evidence is still the best caries diagnostic technique. Current practice is consistent with current evidence.[23]

## 5. Conclusion

These results – obtained during actual clinical procedures rather than from questionnaire-based hypothetical scenarios – quantified the diagnostic techniques most commonly used by practicing dentist in real-world setting during the actual delivery of routine restorative care. We identified significant regional differences in the utilisation of the various diagnostic techniques. These regional differences may be due to differences in dental education and community practice norms. Patient age, gender and having dental insurance are also associated with the use of diagnostic technique.

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## Conflict of interest

None of the authors declare any conflicts of interest.

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