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Rubber dam use during routine operative dentistry procedures: findings from The Dental PBRN

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SUMMARY

Rubber dam use during operative dentistry procedures has been quantified based on questionnaires completed by dentists. However, to our knowledge there are no reports based on use during actual clinical procedures other than in dental materials studies, and none based on routine care. Our objectives were to: (1) quantify how commonly the rubber dam is used during operative dentistry procedures; (2) test the hypothesis that certain dentist-, restoration- and patient-level factors are associated with its use.

A total of 229 dentist practitioner-investigators in “The Dental Practice-Based Research Network (DPBRN)” participated. DPBRN comprises five regions: Alabama/Mississippi, Florida/Georgia, Minnesota, Permanente Dental Associates, and Scandinavia. Practitioner-investigators collected data on 9,890 consecutive restorations done in previously-unrestored tooth surfaces from 5,810 patients.

Most dentists (63%) did not use a rubber dam for any restoration in the study. A rubber dam was used for only 12% of restorations, 83% of which were used in one DPBRN region. With region accounted for, no other dentist characteristics were significant. A multi-level multiple logistic regression of rubber dam use was done with restoration- and patient-level variables modeled simultaneously. In this multi-variable context, these restoration-level characteristics were statistically significant: tooth-arch type, restoration classification, and reason for placing the restoration. These patient-level characteristics were statistically significant: ethnicity, dental insurance, and age.

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The DPBRN Collaborative Group comprises practitioner-investigators, faculty investigators, and staff investigators who contributed to this DPBRN activity. A list of these persons is at <http://www.dpbrn.org/users/publications/Default.aspx>

These results, obtained from actual clinical procedures rather than questionnaires, document a low prevalence of usage of rubber dam during operative dentistry procedures. Usage varied with certain dentist-, restoration-, and patient-level characteristics.

Keywords

rubber dam; restorative dentistry; practice-based research; private practice; dental restoration; dental general practice

INTRODUCTION

Operative dentistry procedures comprise a large percentage of general dentists' treatment time, and a routine aspect of this care is whether or not a rubber dam is used. The potential benefits of using a rubber dam have been detailed elsewhere.^{1,2} Its usage differs depending upon whether the dental procedure is for endodontics or operative dentistry. The endorsement of rubber dam use in endodontic textbooks and by specialty organizations imply that its use during endodontic procedures is the standard of care, but up to 70% of dentists responding to questionnaires report that they actually do not always use a rubber dam during endodontic procedures.¹⁻¹² The reported use of rubber dam for operative dentistry procedures is much lower, where it has been quantified using questionnaires completed by dentists, as well during dental materials clinical studies.^{1,2,4,5,7,10-18} To our knowledge, there are no reports in the literature that are based on use in actual clinical procedures during routine care - the topic of the current study.

A questionnaire survey of Welsh and Irish dental students found that age of the patient was not associated with rubber dam use, but use was substantially higher for composite restorations compared to amalgam restorations.¹⁹ A 2006 survey of Irish general dentists observed differences based on tooth location and restoration material: 77% of dentists reported never using a rubber dam when placing amalgam restorations in posterior teeth, 59% never use a rubber dam when placing anterior composite restorations, and 52% never use a rubber dam for posterior composite restorations.¹

Two studies have observed significantly greater shear bond strengths and reduced microleakage when rubber dam isolation was compared to cotton roll isolation, following clinical procedures from which measurements were made on teeth extracted from these patients.^{20,21} However, rubber dam usage has not been shown to be related to other aspects of initial restoration quality or restoration longevity,^{14,16-18} although these studies were conducted in academic settings, not in typical private practices. Authors of a review of the literature from 1996 to 2002 regarding clinical performance of posterior resin composites concluded that the method of isolation (rubber dam or cotton rolls) was not a significant predictor of long-term failure.¹⁵ To our knowledge, all studies that have investigated the effects of isolation have been observational studies that have not randomized patients to a specific isolation method.

As part of a study involving restoration of previously un-restored tooth surfaces in routine clinical practice, we had an opportunity in "The Dental Practice-Based Research Network (DPBRN)" to quantify the use of the rubber dam in actual clinical procedures, instead of having to rely on dentists' self-reports in questionnaires. Because DPBRN also has a substantial amount of information about the dentists, their practice characteristics, and the characteristics of the patients and clinical procedures done in the study, it also had an opportunity to identify dentist-, patient-, and restoration-level factors associated with the use of the rubber dam.

DPBRN is a consortium of dental practices that have affiliated to investigate research questions, to share experiences and expertise, and that are committed to improving clinical practice through research and collegiality.^{22,23} Many details about DPBRN are publicly available at its web site,²⁴ but briefly, it comprises practitioner-investigators and staff in outpatient dental practices from five regions: AL/MS: Alabama/Mississippi, FL/GA: Florida/Georgia, MN: dentists employed by HealthPartners Dental Group²⁵ and private practitioners in Minnesota, PDA: Permanente Dental Associates²⁶ in Oregon and Washington, and SK: the Scandinavian countries of Denmark, Norway, and Sweden. DPBRN has a wide representation of practice types, treatment philosophies, and patient populations, including diversity with regard to the race, ethnicity, geography and rural/urban area of residence of both its practitioner-investigators and their patients. Analyses of these characteristics confirm that DPBRN dentists have much in common with dentists at large,²⁷ while at the same time offering substantial diversity with regard to these characteristics.²⁸

The objectives of the present investigation were to: (1) quantify how commonly the rubber dam is used during operative dentistry procedures; and (2) test the hypothesis that certain dentist-, restoration-, and patient-level factors are associated with its use.

METHODS & MATERIALS

Dentist recruitment process

Dentist practitioner-investigators in DPBRN were recruited 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 their practice characteristics and themselves. 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) participated in a training session with the DPBRN staff 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.²³ These questionnaires are publicly available at the DPBRN Supplement page.²⁹

Study design

This 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 un-restored permanent tooth surface was asked to participate until 50 restorations had been enrolled. Patients who returned for additional appointments while data collection was still ongoing were not eligible for further data collection. In order to increase the number of patients that would be enrolled, only restorations eligible during the first appointment were enrolled and only a maximum of four eligible restorations per patient during that first appointment were included. A consecutive patient/restoration log form was used to record information on eligible restorations whether or not the patient participated in the study. All of the data collection forms used for this study are available at the DPBRN Supplement page.²⁹

Dentist-level variables

Dentist-level variables were available from the DPBRN Enrollment Questionnaire. In addition to DPBRN region, DPBRN dentists can also be characterized by “type of practice”, for which we categorized each dentist as being in either: (1) a solo or small group private practice (SGP); (2) a large group practice (LGP); or (3) a public health practice (PHP). “Small” practices were defined as those that had three or fewer dentists. “Large” group practices were defined as those that had four or more dentists. Public health practices were defined as those that receive the

majority of their funding from public sources. In the AL/MS region, 98% of practitioner-investigators were in SGP and 2% were in PHP. In the FL/GA region, 97% were in SGP and 3% were in PHP. In the MN region, 90% were in LGP and 10% were in SGP. In the PDA region, all were in LGP. In the SK region, 64% were in SGP and 36% were in PHP.

Year of graduation from dental school, dentist's gender, and dentist's race were also available. Dentist's "workload" was queried as "Which of the following best describes your part of the practice during the past 12 months?", with the response categories evident in Table 2.

Restoration-level variables

For each enrolled restoration, among other items, data were collected about: (1) tooth number; (2) which tooth surfaces were included in the restoration; (3) the main reason for placing the restoration ("restoration of a non-cariou defect" or "primary caries"); (4) which restorative material(s) were used; (5) pre-operative assessment of caries lesion depth, when the main reason for placing the restoration was primary caries (categories evident in Table 2); and (6) rubber dam use, the main outcome variable for this study. This was queried as "Did you use a rubber dam during the restorative procedure?"

Patient-level variables

For each enrolled patient, data were collected about the patient's gender, age, race, Hispanic or Latino ethnicity, and whether or not the patient has "any dental insurance or third party coverage". Response categories for these variables are evident in Table 2.

Statistical methods

All analyses were done using SAS.³⁰ A p-value of 0.05 or less was considered statistically significant. In addition to quantifying frequency distributions, we also cross-tabulated responses.

The SAS[®] GENMOD procedure was used to implement a generalized estimating equations approach to logistic regression, in order to model the associations between rubber dam use and dentist-, restoration-, and patient-level characteristics, while simultaneously accounting for within-dentist 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 up to four restorations in the study (within-patient clustering). Diagnostic analyses of rubber dam use showed a median intraclass correlation coefficient (ICC) of 0.3441 for restoration-level effects and an ICC of 0.0499 for patient-level effects, so including these effects in the logistic regressions of rubber dam usage was warranted. ICCs were calculated using mixed-model analysis of variance, and reflect correlations among residuals of models incorporating restoration- or patient-level variables, and not accounting for clustering. Ordinarily, bivariate cross-tabulations done as in Table 2 would be tested for statistical significance using χ^2 tests and Mantel-Haenszel χ^2 trend tests. However, this was not appropriate in this context because of the within-class clustering. Therefore, statistical tests in Table 2 were done using GEE-based logistic regressions to account for the effect of this clustering.

A note regarding the stepwise nature of our modeling technique is warranted. We adopted stepwise variable selection within each unit of analysis for the sake of parsimony because we had multiple measures of characteristics at each of the dentist, restoration, and patient levels. Because of substantial overlap between DPBRN region and type of practice, the effects of these two variables could not be tested at the same time in the same regression.

RESULTS

A total of 229 DPBRN practitioner-investigators recorded information for 9,890 consecutive restorations placed in previously un-restored permanent tooth surfaces in 5,810 patients, as detailed in Table 1. Not shown in the table, practitioner-investigators placed a mean (S.D.) of 43.2 (14.8) restorations for this study, and 95% of eligible consecutive patients were enrolled in the study.

Dentist-level results

A total of 63% (n = 144) of practitioner-investigators did not use a rubber dam for any restoration. This percentage varied significantly by DPBRN region (AL/MS = 75%; FL/GA = 68%; MN = 81%; PDA = 12%; SK = 87%; logistic regression analysis, $p < 0.0001$). The percentage in FL/GA was not significantly different from that in AL/MS. Rates in the other regions were significantly different from that in AL/MS: MN ($p = 0.0432$), PDA ($p < 0.0001$), and SK ($p = 0.0007$).

Six dentist characteristics were tested for their association with rubber dam use (Table 2). In these bivariate analyses, DPBRN region, practice type, and dentist's race were strongly associated with rubber dam use. Logistic regression analysis was used to characterize practitioners who used a rubber dam for at least one restoration. Potential predictor variables were the six dentist-level characteristics in Table 2. Each potential predictor was included in a model along with "region". No variable was significant with "region" in the model, suggesting that "region" is the key dentist-level characteristic associated with rubber dam use.

Of the 37% (n = 85) of practitioner-investigators who used a rubber dam for at least one restoration, the mean (S.D.) percentage of restorations for which a rubber dam was used by each practitioner-investigator was 30.7 (29.6). This mean varied significantly by DPBRN region (AL/MS = 8.6 (10.7); FL/GA = 17.3 (29.6); MN = 21.9 (23.2); PDA = 46.5 (27.8); SK = 6.7 (5.3); $p < 0.0001$ chi-sq).

Restoration-level bivariate results

A rubber dam was used for 12% of the 9,602 restorations that had complete data about rubber dam use (of the total of 9,890 restorations). This percentage varied significantly by DPBRN region (AL/MS = 2%; FL/GA = 5%; MN = 4%; PDA = 42%; SK = 1%; $p < 0.0001$ chi-sq).

To evaluate the association between rubber dam use and restoration characteristics, analysis was limited to the 3,714 restorations that were placed by the 85 dentists who placed a rubber dam on at least one restoration in the study, and for which the practitioner indicated whether a rubber dam had been used. Descriptive statistics for the 3,817 restorations placed by these dentists, including 103 with no indication of whether a rubber dam was used, are shown in Table 2. A total of 31% of the 3,714 (3,817–103) restorations placed by these 85 dentists received a rubber dam. Limiting the analysis in this manner was necessary because dentist characteristics – not restoration characteristics – explain the fact that no rubber dam was placed on the restorations that were placed by the 144 dentists who did not place a rubber dam on any restoration.

Six restoration characteristics were tested for their association with rubber dam use (Table 2). In these bivariate analyses (statistical testing done with GEE logistic regression), these restoration characteristics were significantly associated with whether or not a rubber dam was used for that restoration: tooth-arch type; restoration classification; number of surfaces in restoration; reason for placing the restoration; and depth of primary caries lesion estimated pre-operatively. Material used in the restoration was not statistically significant at the $p < 0.05$ level ($p = 0.062$).

Patient-level bivariate results

A rubber dam was used for 12% of the 5,810 patients. This percentage varied significantly by DPBRN region (AL/MS = 2%; FL/GA = 6%; MN = 4%; PDA = 46%; SK = 1%; $p < 0.0001$; generalized mixed model that accounted for clustering by dentist).

To evaluate the association between rubber dam usage and patient characteristics, analysis was limited to the 2,109 patients who were treated by the 85 dentists who placed a rubber dam on at least one restoration in the study. A total of 33% of the 2,109 patients treated by these 85 dentists received a rubber dam. Limiting the analysis in this manner was necessary because dentist characteristics – not patient characteristics - explain the fact that no rubber dam was used with the patients treated by the 144 dentists who did not place a rubber dam on any restoration.

Five patient characteristics were tested for their association with rubber dam use (Table 2). In these bivariate analyses (statistical testing done with GEE logistic regression), these patient characteristics were significantly associated with whether or not a rubber dam was used with that patient: ethnicity, dental insurance, and age.

Multi-level multiple logistic regression

A multi-level multiple logistic regression of rubber dam use was done with restoration- and patient-level variables modeled simultaneously (Table 3). In this multi-variable context, these restoration-level characteristics were statistically significant: tooth-arch type, restoration classification, and reason that the restoration was placed. For tooth-arch type, rubber dam usage was highest for maxillary anterior restorations, with the other variables in the model taken into account. Restorations that were Class I, II, or IV were significantly more likely to have had a rubber dam placed, as were restorations for which the reason for placement was primary caries.

In this multi-variable context, these patient-level characteristics were statistically significant: ethnicity, dental insurance, and age. With the other restoration-level and patient-level characteristics taken into account, persons who were of Hispanic or Latino ethnicity were more likely to have received a rubber dam for a restoration placement, as were persons with some type of dental insurance, and persons who were younger than 65 years old.

DISCUSSION

These findings demonstrate that use of a rubber dam during operative dentistry procedures is not common. These clinical findings essentially corroborate conclusions based on studies that have relied on dentists' responses to questionnaires. To our knowledge, the most-recent study of rubber dam use involved a questionnaire completed by U.S. general dentists in 2007, in which 53% of dentists reported never using a rubber dam for amalgam restorations, 45% never do so for anterior direct resin composites, and 39% never do so for posterior direct resin composites.⁴ In a 2001 survey of British general dentists, 53% reported that they never use a rubber dam when placing posterior composite restorations.¹³ An earlier British survey found that 93% of dentists in the British Dental Association “never or seldom” use a rubber dam for operative dental procedures, compared to 82% “never or seldom” for endodontic procedures.¹⁰ A study of more than 1,000 alumni of one U.S. dental school observed that 40%–45% of dentists never use a rubber dam for restorative procedures, depending on the procedure, compared to 11% who never use it for endodontic procedures.¹¹ Surveys of dental students suggest that while rubber dam usage for operative procedures during dental school is high, these same students do not expect to use a rubber dam commonly for these same procedures once in private practice.^{4,19} Therefore, our findings from actual clinical procedures support

similar findings from questionnaire studies that have included a broad range of practitioner types and geographic locations.

A 2007 survey of U.S. dentists observed that the most-common reasons for not using a rubber dam were “inconvenience” and that “it was unnecessary”.⁴ Time and cost received the least-important ratings. The time saved by operating in a clean field with good visibility may compensate for the time spent applying the rubber dam.²¹ A 1995 survey of alumni of a mid-western U.S. dental school observed that the most-common reason for non-use of certain techniques taught in dental school (such as use of a rubber dam) was “not essential to efficient dentistry”.⁷ Patient acceptance has been reported as the main reason in other studies,¹⁰ although studies that actually query patients have found patient acceptance to be high.^{31,32} Patient safety would be one reason to use a rubber dam during operative procedures. One study found that using a rubber dam during removal of an amalgam restoration significantly reduced the peak mercury level rise in the patient’s plasma.³³ One group of investigators has recommended rubber dam use when restoring Class V lesions in older patients to prevent subcutaneous air emphysema.³⁴ Although these events are rare in operative dentistry procedures,^{35,36} reduction in swallowed or aspirated dental devices is a clear benefit of rubber dam use.

Our findings suggest that use of a rubber dam is associated with certain dentist-, patient- and restoration-level characteristics. A 1984 survey of U.S. Air Force general dentists asked respondents to report on their use of the rubber dam in percentage categories.¹² Respondents reported detailed usage, including usage by restoration material type, restoration classification, and procedure type. An overall conclusion was that rubber dam usage was very high compared to usage reported by other types of dentists. For example, for class II amalgam restorations in maxillary teeth, 87% of dentists responded that they use a rubber dam at least 21% of the time. Usage by Air Force dentists was unusually high compared to dentists at large. An analogous circumstance exists for our DPBRN practitioner-investigators, in which those in the PDA region have a substantially higher usage compared to practitioner-investigators in the other DPBRN regions. Our study, in conjunction with the Air Force study, supports the conclusion that, while use by dentists overall is low, certain groups of dentists have use that is quite high. Providing care within a large group practice may be associated with higher use. These findings are consistent with the notion that there is not an intrinsic clinical reason that rubber dam use has to be rare in operative dentistry procedures. Instead, key dentist-level or practice-level factors may determine use, and interventions designed to increase use likely would not face an intrinsic clinical barrier.

One study in the literature suggests that age of the patient is not associated with rubber dam use.¹⁹ However, our DPBRN study found that - while there was not a linear relationship between age of the patient and rubber dam use - use was significantly higher among patients who were younger than 65 years old. We could speculate as to why this occurred, but the fact that key restoration-level characteristics and patient-level characteristics were simultaneously taken into account in the regression in Table 3 removes several reasons from further consideration.

A questionnaire survey of Welsh and Irish dental students found that use was substantially higher for composite restorations compared to amalgam restorations.¹⁹ A 2006 survey of Irish general dentists observed differences based on tooth location and restoration material: 77% of dentists reported never using a rubber dam when placing amalgam restorations in posterior teeth, 59% never use a rubber dam when placing anterior composite restorations, and 52% never use a rubber dam for posterior composite restorations.¹ Our current results with DPBRN practitioner-investigators did not find similar results; instead, restoration material was not significant, but the related factors of restoration classification and tooth-arch type were significant. These differences underscore the unique, additive contribution made from our

DPBRN study. That is, our DPBRN study was able to account for tooth-arch type, the reason that the restoration was being placed, as well as the associations with patient's ethnicity and insurance coverage. With these factors taken into account, restoration material was not as important a factor.

One limitation of this study is that other forms of isolation were not queried. We restricted the study to rubber dam isolation because this is by far the most commonly used method for isolation of teeth and their surrounding areas.³⁷ Additionally, the effectiveness of other types of isolation of the operating field has not been ascertained. Further studies of these factors would be warranted.

CONCLUSION

These results, obtained in routine clinical practice from actual clinical procedures rather than questionnaires, document a low prevalence of usage of rubber dam during operative dentistry procedures. Nonetheless, use of the rubber dam significantly varied with certain dentist-, restoration-, and patient-level characteristics.

Clinical Relevance

A routine aspect of procedures involving placement of dental restorations is whether or not a rubber dam is used. This study documents the use of a rubber dam by dentists in non-academic routine clinical practice, finding that its use is low and significantly associated with certain dentist, restoration, and patient characteristics.

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References

1. Lynch CD, McConnell RJ. Attitudes and use of rubber dam by Irish general dental practitioners. *International Endodontic Journal* 2007;40(6):427–432. [PubMed: 17501755]
2. Soldani F, Foley J. An assessment of rubber dam usage amongst specialists in paediatric dentistry practising within the UK. *International Journal of Paediatric Dentistry* 2007;17(1):50–56. [PubMed: 17181579]
3. Palmer NO, Ahmed M, Grieveson B. An investigation of current endodontic practice and training needs in primary care in the north west of England. *British Dental Journal* 2009;206(11):E22. discussion 584–585. [PubMed: 19478812]
4. Hill EE, Rubel BS. Do dental educators need to improve their approach to teaching rubber dam use? *Journal of Dental Education* 2008;72(10):1177–1181. [PubMed: 18923098]
5. Wilson NH, Christensen GJ, Cheung SW, Burke FJ, Brunton PA. Contemporary dental practice in the UK: aspects of direct restorations, endodontics and bleaching. *British Dental Journal* 2004;97(12):753–756. [PubMed: 15608740]
6. Koshy S, Chandler NP. Use of rubber dam and its association with other endodontic procedures in New Zealand. *New Zealand Dental Journal* 2002;98(431):12–16. [PubMed: 12017902]
7. Clark DM, Oyen OJ, Feil P. The use of specific dental school-taught restorative techniques by practicing clinicians. *Journal of Dental Education* 2001;65(8):760–765. [PubMed: 11518247]
8. Jenkins SM, Hayes SJ, Dummer PM. A study of endodontic treatment carried out in dental practice within the UK. *International Endodontic Journal* 2001;34(1):16–22. [PubMed: 11307376]

9. Whitworth JM, Seccombe GV, Shoker K, Steele JG. Use of rubber dam and irrigant selection in UK general dental practice. *International Endodontic Journal* 2000;33(5):435–441. [PubMed: 11307462]
10. Marshall K, Page J. The use of rubber dam in the UK: a survey. *British Dental Journal* 1990;169(9):286–291. [PubMed: 2261277]
11. Joynt RB, Davis EL, Schreier PH. Rubber dam usage among practicing dentists. *Operative Dentistry* 1989;14(4):176–181. [PubMed: 2639317]
12. Hagge MS, Pierson WP, Mayhew RB, Cowan RD, Duke ES. Use of rubber dam among general dentists in the United States Air Force dental service. *Operative Dentistry* 1984;9(4):122–129. [PubMed: 6596553]
13. Burke FJT, McHugh S, Hall AC, Randall RC, Widstrom E, Forss H. Amalgam and composite use in UK general dental practice in 2001. *British Dental Journal* 2003;194(11):613–618. [PubMed: 12819697]
14. Huth KC, Manhart J, Selbertinger A, Paschos E, Kaaden C, Kunzelmann KH, Hickel R. 4-year clinical performance and survival analysis of Class I and II compomer restorations in permanent teeth. *American Journal of Dentistry* 2004;17(1):51–55. [PubMed: 15241910]
15. Brunthaler A, König F, Lucas T, Sperr W, Schedle A. Longevity of direct resin composite restorations in posterior teeth. *Clinical Oral Investigations* 2003;7(2):63–70. [PubMed: 12768463]
16. Raskin A, Setcos JC, Vreven J, Wilson NH. Influence of the isolation method on the 10-year clinical behaviour of posterior resin composite restorations. *Clinical Oral Investigations* 2000;4(3):148–52. [PubMed: 11000319]
17. Smales RJ. Rubber dam usage related to restoration quality and survival. *British Dental Journal* 1993;174(9):330–333. [PubMed: 8484999]
18. van Dijken JW, Hörstedt P. Effect of the use of rubber dam versus cotton rolls on marginal adaptation of composite resin fillings to acid-etched enamel. *Acta Odontologica Scandinavica* 1987;45(5):303–308. [PubMed: 3478936]
19. Mala S, Lynch CD, Burke FM, Dummer PM. Attitudes of final year dental students to the use of rubber dam. *International Endodontic Journal* 2009;42(7):632–638. [PubMed: 19467044]
20. Barghi N, Knight GT, Berry TG. Comparing two methods of moisture control in bonding to enamel: a clinical study. *Operative Dentistry* 1991;16(4):130–135. [PubMed: 1805181]
21. Knight GT, Berry TG, Barghi N, Burns TR. Effects of two methods of moisture control on marginal microleakage between resin composite and etched enamel: a clinical study. *International Journal of Prosthodontics* 1993;6(5):475–479. [PubMed: 8297458]
22. Gilbert GH, Williams OD, Rindal DB, Pihlstrom DJ, Benjamin PL, Wallace MA. for the DPBRN Collaborative Group. The creation and development of The Dental Practice-Based Research Network. *Journal of the American Dental Association* 2008;139(1):74–81. [PubMed: 18167389]
23. Gilbert GH, Qvist V, Moore SD, Rindal DB, Fellows JL, Gordan VV, Williams OD. for the DPBRN Collaborative Group. Institutional review board and regulatory solutions in The Dental PBRN. *Journal of Public Health Dentistry*. 2009 Aug 20; [Epub ahead of print].
24. Dental Practice-Based Research Network. 2010. Retrieved online January 15, 2010 from www.DentalPBRN.org
25. HealthPartners®. 2009. Retrieved online January 15, 2010 from <http://www.healthpartners.com/>
26. PDA: Permanente Dental Associates. 2009. Retrieved online January 15, 2010 from <http://xnet.kp.org/pda/index.html>
27. Makhija SK, Gilbert GH, Rindal DB, Benjamin PL, Richman JS, Pihlstrom DJ, Qvist V. for the DPBRN Collaborative Group. Dentists in practice-based research networks have much in common with dentists at large: evidence from The Dental PBRN. *General Dentistry* 2009;57(3):270–275. [PubMed: 19819818]
28. Makhija SK, Gilbert GH, Rindal DB, Benjamin PL, Richman JS, Pihlstrom DJ, Qvist V. for the DPBRN Collaborative Group. Practices participating in a dental PBRN have substantial and advantageous diversity even though as a group they have much in common with dentists at large. *BMC Oral Health* 2009;9(1):26–35. [PubMed: 19832991]
29. Dental Practice-Based Research Network. Supplements to specific DPBRN publications. 2009. Retrieved online January 15, 2010 from www.dentalpbrn.org/users/publications/Supplement.aspx

30. SAS Institute, Inc.. SAS/STAT version 9.1. SAS Publishing; Cary, NC: 2006. Retrieved online January 15, 2010 from www.sas.com/apps/pubscat/complete.jsp
31. Stewardson DA, McHugh ES. Patients' attitudes to rubber dam. *International Endodontic Journal* 2002;35(10):812–819. [PubMed: 12406374]
32. Gergely EJ. Desmond Greer Walker Award. Rubber dam acceptance. *British Dental Journal* 1989;167(7):249–52. [PubMed: 2789907]
33. Berglund A, Molin M. Mercury levels in plasma and urine after removal of all amalgam restorations: the effect of using rubber dams. *Dental Materials* 1997;13(5):297–304. [PubMed: 9823089]
34. Chan DC, Myers T, Sharaway M. A case for rubber dam application--subcutaneous emphysema after Class V procedure. *Operative Dentistry* 2007;32(2):193–196. [PubMed: 17427830]
35. Susini G, Pommel L, Camps J. Accidental ingestion and aspiration of root canal instruments and other dental foreign bodies in a French population. *International Endodontic Journal* 2007;40(8):585–589. [PubMed: 17532776]
36. Hill EE, Rubel B. A practical review of prevention and management of ingested/aspirated dental items. *General Dentistry* 2008;56(7):691–694. [PubMed: 19014028]
37. Summitt, JB. Field Isolation. In: Summitt, JB.; Robbins, JW.; Hilton, TJ.; Schwarts, RS., editors. *Fundamentals of Operative Dentistry - A Contemporary Approach*. 3. Vol. Chapter 7. Quintessence; Chicago: 2006. p. 156-157.

Table 1

Number and percentage of practitioner-investigators, restorations, and patients participating in this study, overall and by DPBRN region.

	Overall	AL/MS	FL/GA	MN	PDA	SK
Dentists [N (%)]	229 (100)	63 (27.5)	37 (16.2)	31 (13.5)	51 (22.3)	47 (20.5)
Restorations [N (%)]	9,890 (100)	2,801 (28.3)	1,720 (17.4)	1,745 (17.6)	2,312 (23.4)	1,312 (13.3)
Patients [N (%)]	5,810 (100)	1,507 (25.9)	1,022 (17.6)	1,084 (18.7)	1,233 (21.2)	964 (16.6)

AL/MS: Alabama/Mississippi; FL/GA: Florida/Georgia; MN: HealthPartners and private practitioners in

Minnesota; PDA: Permanente Dental Associates and Kaiser Permanente's Center for Health Research; and SK: Denmark, Norway, and Sweden. Percentages are within rows for each variable.

Table 2

Use of rubber dam, by dentist-, restoration-, and patient-level characteristic

Characteristic (n)	Percentage of rubber dam usage in row
<i>Dentist-level^a</i>	
Overall (n=229)	37%
<i>Dentist's region</i>	
AL/MS (n=63)	25% *
FL/GA (n=37)	32%
MN (n=31)	19%
PDA (n=51)	88%
SK (n=47)	13%
<i>Dentist's type of practice</i>	
Large group practice (n=79)	62% *
Solo or small group practice (n=131)	26%
Public health practice (n=19)	11%
<i>Dentist's year of graduation from dental school</i>	
Before 1974 (n=20)	35% <i>ns</i>
1974–1983 (n=85)	28%
1984–1993 (n=62)	44%
1994 or later (n=58)	47%
missing (n=4)	
<i>Dentist's gender</i>	
Male (n=172)	36% <i>ns</i>
Female (n=57)	40%
<i>Dentist's race</i>	
White (n=200)	35% *
All non-White (n=25)	60%
missing (n=4)	
<i>Dentist's workload</i>	
Too busy to treat all (n=27)	33% <i>ns</i>
Provided care to all, but overburdened (n=45)	33%
Provided care to all, but not overburdened (n=117)	40%
Not busy enough (n=28)	39%
missing (n=12)	
<i>Restoration-level^b</i>	
Overall (n=3,817)	31%
<i>Tooth and arch type</i>	
Maxillary molar (n=976)	25% *
Maxillary premolar (n=569)	39%
Maxillary anterior (n=592)	36%
Mandibular molar (n=988)	32%

Characteristic (n)	Percentage of rubber dam usage in row
Mandibular premolar (n=393)	33%
Mandibular anterior (n=196)	14%
missing (n=103)	
<i>Restoration classification</i>	
Class I (n=1,072)	24% *
Class II (n=1,277)	44%
Class III (n=385)	39%
Class IV (n=186)	27%
Class V (n=742)	15%
missing (n=155)	
<i>Number of surfaces in restoration</i>	
One (n=2,455)	29% *
Two (n=941)	33%
Three (n=226)	39%
Four (n=63)	43%
Five (n=14)	71%
Six (n=4)	75%
missing (n=114)	
<i>Material used for restoration</i>	
Amalgam only (n=1,508)	41% <i>ns</i>
Direct resin composite only (n=1,993)	26%
All other (n=203)	16%
missing (n=113)	
<i>Reason that the restoration was placed</i>	
Primary caries (n=3,224)	34% *
Non-carious defect (n=576)	17%
missing (n=17)	
<i>Depth of primary caries lesion estimated pre-operatively</i>	
Outer half of enamel (n=92)	21% *
Inner half of enamel (n=330)	26%
Outer one-third of dentin (n=1,816)	34%
Middle one-third of dentin (n=706)	33%
Inner one-third of dentin (n=236)	40%
Dentist was uncertain (n=28), missing (n=33), or not applicable because the lesion was a non-carious defect (n=576)	
<i>Patient-level^c</i>	
Overall (n=2,109)	33%
<i>Patient's gender</i>	
Male (n=981)	33% <i>ns</i>
Female (n=1,068)	31%
missing (n=60)	
<i>Patient's race</i>	

Characteristic (n)	Percentage of rubber dam usage in row
White (n=1,626)	33% ^{ns}
All non-White (n=370) missing (n=113)	29%
<i>Patient's ethnicity</i>	
Hispanic or Latino (n=116)	50% *
Not Hispanic or Latino (n=1,888) missing (n=105)	31%
<i>Patient has dental insurance or third party coverage</i>	
Yes (n=1,751)	34% *
No (n=297) missing (n=61)	20%
<i>Patient's age</i>	
Less than 18 years old (n=430)	25% *
18–45 years old (n=1,042)	38%
45–64 years old (n=464)	27%
65 years old or older (n=104) missing (n=69)	15%

*
p < 0.05

^{ns}not statistically significant

^aDentist-level analyses used data from all 229 participating dentists.

^bRestoration-level analyses only used data from the 3,714 restorations that were placed by the 85 dentists who placed a rubber dam on at least one restoration, and for which the dentist indicated whether a rubber dam had been used. Therefore, although 12% of all restorations received a rubber dam, a total of 31% of the 3,714 restorations placed by these 85 dentists received a rubber dam. This is necessary because dentist characteristics – not restoration characteristics - explain the fact that no rubber dam was placed on the restorations that were placed by the 144 dentists who did not place a rubber dam on any restoration.

^cPatient-level analyses only used data from the 2,109 patients who were treated by the 85 dentists who placed a rubber dam on at least one restoration. Therefore, although 12% of all 5,810 patients received a rubber dam, a total of 33% of the 2,109 patients treated by these 85 dentists received a rubber dam. This is necessary because dentist characteristics – not patient characteristics - explain the fact that no rubber dam was placed on the patients who were treated by the 144 dentists who did not place a rubber dam on any patient.

Table 3

Multi-level multiple logistic regression of rubber dam use with restoration- and patient-level variables modeled simultaneously, by restoration-level and patient-level characteristics

Explanatory covariate	Parameter Estimate	Standard Error	p-value
Intercept	-2.61	0.37	<0.001
<i>Restoration-level</i>			
<i>Tooth and arch type</i>			
Maxillary molar	-0.18	0.40	ns
Maxillary premolar	-0.03	0.39	ns
Maxillary anterior	0.66	0.30	0.029
Mandibular molar	0.25	0.41	ns
Mandibular premolar	0.08	0.39	ns
Mandibular anterior [reference group]			
<i>Restoration classification</i>			
Class I	0.77	0.17	<0.001
Class II	1.42	0.19	<0.001
Class III	0.49	0.30	ns
Class IV	0.92	0.35	0.008
Class V [reference group]			
<i>Reason that the restoration was placed</i>			
Primary caries	0.57	0.19	0.002
Non-cariou defect [reference group]			
<i>Patient-level</i>			
<i>Patient's ethnicity</i>			
Hispanic or Latino	0.42	0.15	0.006
Not Hispanic or Latino [reference group]			
<i>Patient has dental insurance or third party coverage</i>			
Yes	0.37	0.15	0.015
No [reference group]			
<i>Patient's age</i>			
Less than 18 years old	0.92	0.18	<0.001
18–45 years old	0.95	0.16	<0.001
45–64 years old	0.73	0.21	0.004
65 years old or older [reference group]			

The outcome of interest (use of a rubber dam) was coded 1 if a rubber dam was used on the restoration/patient, and 0 if not. n = 3,597; model fit: QIC = 4,184. This logistic regression was limited to the 3,714 restorations that were placed for the 2,109 patients by the 85 dentists who placed a rubber dam on at least one restoration at any time during the study. This was done with the GENMOD procedure in SAS, using a logit link, binomial distribution, exchangeable correlation structure. Although the restoration is the unit of analysis, clustering of restorations within patients and dentists is accounted for in the correlation structure, allowing for both restoration-specific and patient-specific characteristics to be tested.