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## Reasons for Placement of Restorations on Previously Unrestored Tooth Surfaces by Dental PBRN Dentists

**Marcelle M. Nascimento, DDS, MS, PhD [Assistant Professor],**

Department of Operative Dentistry, College of Dentistry, University of Florida, Gainesville, Florida, USA

**Valeria V. Gordan, DDS, MS, MS-CI [Professor]\*,**

Department of Operative Dentistry, College of Dentistry, University of Florida, Gainesville, Florida, USA

**Vibeke Qvist, DDS, PhD, Dr. Odont [Associate Professor],**

Department of Cariology and Endodontics, School of Dentistry, Faculty of Health Sciences, University of Copenhagen, Copenhagen, Denmark

**Mark S. Litaker, Ph.D. [Associate Professor],**

Department of General Dental Sciences, School of Dentistry, University of Alabama at Birmingham, Birmingham, Alabama, USA

**D. Brad Rindal, DDS [Investigator and dental health provider],**

HealthPartners, Minneapolis, Minnesota, USA

**O.D. Williams, MPH, PhD [Professor and Interim Director],**

Division of Preventive Medicine, School of Medicine, University of Alabama at Birmingham, Birmingham, Alabama, USA

**Jeffrey L. Fellows, PhD [Investigator],**

Center for Health Research, Kaiser Permanente Northwest, Portland, Oregon, USA

**Lloyd K. Ritchie Jr., DDS,**

DPBRN practitioner-investigator in private practice in Pensacola, Florida, USA

**Ivar A. Mjör, BDS, MS, MSD, Dr. odont [Emeritus Professor],**

Department of Operative Dentistry at University of Florida, Gainesville, Florida, USA

**Jocelyn McClelland, DDS,**

DPBRN practitioner-investigator in private practice in Alabaster, Alabama, USA

**Gregg H. Gilbert, DDS, MBA [Professor and Chair], and**

Department of General Dental Sciences, School of Dentistry, University of Alabama at Birmingham, Birmingham, Alabama, USA

**For the DPBRN COLLABORATIVE GROUP**

### Abstract

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\*Corresponding author: Valeria V. Gordan, University of Florida, College of Dentistry, P.O.Box 100415, Gainesville, FL 32610-04415, Phone: 352 273 5846, Fax: 352 846 1643, [vgordan@dental.ufl.edu](mailto:vgordan@dental.ufl.edu).

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>

**Objective**—To identify and quantify the reasons for placing restorations on unrestored permanent tooth surfaces and the dental materials used by Dental Practice-Based Research Network (DPBRN; www.DentalPBRN.org) dentists.

**Methods**—A total of 229 DPBRN practitioner-investigators collected data on 9,890 consecutive restorations from 5,810 patients. Information included: (1) reasons for restoring; (2) tooth and surfaces restored; and (3) restorative materials employed.

**Results**—Primary caries (85%) and non-cariou defects (15%), which included abrasion/abfraction/erosion lesions and tooth fracture, were the main reasons for placement of restorations. Restorations due to caries were frequently placed on occlusal surfaces (49%), followed by distal, mesial, buccal/facial, lingual/palatal, and incisal surfaces. Amalgam was used for 46% of the molar and 45% of the premolar restorations. Directly placed resin-based composite (RBC) was used for 48% of the molar, 49% of the premolar, and 92% of the anterior restorations.

**Conclusion**—Dental caries on occlusal and proximal surfaces of molar teeth are the main reasons for placing restorations on previously unrestored tooth surfaces by DPBRN practitioner-investigators. RBC is the material most commonly used for occlusal and anterior restorations. Amalgam remains the material of choice to restore proximal caries in posterior teeth, although there are significant differences by DPBRN region.

### Keywords

primary caries; non-cariou defects; initial restoration; resin-based composite; amalgam; DPBRN

### Introduction

Restorative dentistry represents the bulk of treatment offered by general practitioners and includes mainly the treatment of primary caries and replacement of defective restorations.<sup>1-3</sup> As a result, such operative procedures may have a significant effect on dental tissue removal and longevity of tooth structure in the population.<sup>4</sup> There has been continued progress in restorative dentistry by moving from GV Black's tenets of "extension for prevention" to a minimal intervention approach that encourages preservation of tooth structure.<sup>4, 5</sup> Of particular importance is the clinical decision of when to place the first restoration on a previously unrestored tooth surface. The finite lifespan of a restoration suggests that premature operative interventions would lead to an early start of the restoration life cycle, which typically entails successive restoration replacements and reduced survival times.<sup>6, 7</sup> Alternatively, establishing a vigorous preventive and oral health maintenance plan can markedly extend the life cycle of a tooth by delaying or minimizing restorative procedures.<sup>8-10</sup>

The decision to insert a restoration in an unrestored tooth surface may affect the prognosis of the tooth and the cost of treatment over its lifetime.<sup>9</sup> Much depends on the criteria on which the first restoration was placed and the restorative materials employed. Therefore, a close examination of reasons routinely involved in the initial placement of restorations by general dentists is desirable. Despite scientific developments in cariology and dental materials, marked variations remain among clinicians regarding the diagnosis of dental caries, when to intervene surgically instead of preventively, and the selection of restorative materials. Clinical dentistry could benefit substantially from the development of standardized criteria for caries diagnosis, prevention, and management, which may lead to better clinical outcomes.<sup>6, 10-12</sup>

The Dental Practice-Based Research Network (DPBRN) is a consortium of dental practices that have affiliated to investigate research questions, to share experiences and expertise, and are committed to improving clinical practice through research and collegiality.<sup>13</sup> Clinical decisions by DPBRN dentists for placement of the first restoration in a tooth surface can provide

important knowledge for treatment planning, trends in the use of dental materials, as well as for assessment of how the concepts of minimally invasive dentistry have been incorporated by dentists. Accordingly, the aims of the present investigation were to identify and quantify (1) the reasons for restoring previously unrestored permanent tooth surfaces and (2) the dental materials used by DPBRN practitioner-investigators.

## Materials and Methods

### Selection and recruitment process

The study design was cross-sectional. Practitioner-investigators participating in the DPBRN recorded data for consecutively placed restorations during the clinical visit. The DPBRN comprises outpatient dental practices from five regions: Alabama/Mississippi: AL/MS, Florida/Georgia: FL/GA, dentists employed by HealthPartners and private practitioners in Minnesota: MN, Permanente Dental Associates in cooperation with Kaiser Permanente Center for Health Research, Portland, Oregon: PDA, and Denmark, Norway, and Sweden: SK.<sup>13</sup> Practice structures differed by DPBRN region. Dentists from the AL/MS and FL/GA regions were primarily in independent or small group practices, MN and PDA dentists were primarily in large group practices, and SK dentists were in public or private health care settings. This study was approved by the respective Institutional Review Board of the participating regions.

DPBRN practitioner-investigators were recruited through continuing education courses and/or mass mailings to licensed dentists within the participating regions. As part of the eligibility criteria, all dentists completed (1) an enrollment questionnaire describing their demographic and practice characteristics and certain personal characteristics, (2) an assessment of caries diagnosis and caries treatment questionnaire, (3) training in human subjects protection, and (4) attended a DPBRN orientation session with the regional coordinator in their practice.<sup>14</sup> Additional requirements varied by DPBRN region and are described elsewhere.<sup>15</sup> These questionnaires and further details about the training sessions are available at <http://www.DentalPBRN.org>. Copies of the questionnaires and summary data for dentists' demographic and practice characteristics are also available at <http://www.DentalPBRN.org> and elsewhere.<sup>14, 16</sup>

This study used a consecutive patient/restoration recruitment design. Once the study was started, every patient scheduled to have a restoration on a previously unrestored permanent tooth surface was asked to participate until 50 restorations were 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 the data collection forms used for this study are available at <http://www.DentalPBRN.org/users/publications/Supplement.aspx>.

### Variable selection

Practitioner-investigators collected data for each enrolled restoration on unrestored permanent tooth surfaces. Data collected included: (1) the main reason for placement of the restoration; if due to primary caries, which was defined as caries not associated with an existing restoration; or due to a non-cariou defect, *i.e.* abrasion/ abfraction/ erosion, traumatic tooth fracture, developmental defect or hypoplasia, cosmetic reasons, restoration of endodontically-treated tooth or other unspecified defects or reasons; (2) tooth type and tooth surfaces being restored; and (3) the selection of the restorative materials. Dentists diagnosed primary caries or non-

carious defects based on the diagnostic methods they typically use in their practice, which consist mainly of visual-tactile in association with radiographic examinations.

Restorative materials selected included amalgam, directly placed resin-based composite (RBC), indirectly placed resin-based composite (IRBC), glass-ionomer or resin-modified glass-ionomer (GI/RMGI), ceramic or porcelain, cast gold or other metallic-based material, combined metal-ceramic material, and temporary restorative materials. In addition, practitioners reported whether a base, lining or bonding material was applied prior to the restorative material, and the type of agent used, *i.e.* resin-based bonding material, GI/RMGI, calcium hydroxide-based cement or liner, varnish, and any other non-specified material.

Information about gender, age, race, ethnicity, and insurance coverage of enrolled patients were also recorded. Characteristics of the DPBRN practitioner-investigators who participated in this study have been previously described.<sup>14</sup>

### Statistical analysis

Data were analyzed using SAS software version 9.1 (Cary, N.C.). A p-value of 0.05 or less was considered statistically significant. Distributions of response categories were summarized using counts and percentages, which were compared between regions using chi-square tests. Chi-square tests were also used to evaluate associations among response categories and to evaluate equality of percentages across categories.

### Results

A total of 229 DPBRN practitioner-investigators recorded information for 9,890 restorations placed on unrestored permanent tooth surfaces from 5,810 patients as detailed in Table 1. Ninety-five percent of eligible consecutive patients were enrolled in the study. The distributions of patients' gender, age, race, ethnicity, and insurance coverage are described in Table 2.

Of the 9,980 restorations in this study, 9,830 had complete data on reasons for placement; of these, 8,351 (85%) were placed because of primary caries and 1,479 (15%) were placed due to non-carious tooth defects ( $p < 0.001$  for test of equality of percentages). Among the 1,479 restorations placed due to one or more non-carious defects, 48% were placed due to abrasion/abfraction/erosion lesions, 29% for tooth fracture, 12% for cosmetic reasons, 5% for developmental defects or hypoplasia, 3% were restorations of endodontically-treated teeth, and 10% were inserted due to other unspecified defects or reasons.

Of the 8,351 restorations placed because of primary caries, 57% were placed on molar teeth, 25% on premolar teeth and 17% on anterior teeth. The distributions of restorations by tooth type was significantly different ( $p < 0.0001$ ) by DPBRN region, because SK dentists placed more restorations in premolars and fewer in anterior teeth than did dentists from other DPBRN regions.

The majority of the restorations placed due to primary caries involved only one (67%) or two tooth surfaces (26%), while restorations involving more than two surfaces (7%) represented only a small percentage of the total restorations placed because of primary caries ( $p < 0.0001$  for test of equality of percentages of restorations involving one or two surfaces versus more than two surfaces). Even though the occlusal surfaces (49%) of posterior teeth were the most commonly restored, restorations that included other tooth surfaces were also reported: distal (30%), mesial (25%), buccal/facial (22%), lingual/palatal (14%) surfaces, and incisal edges (2%). With respect to the 8,311 restorations with complete data on the number of tooth surfaces

involved, 39% were Class II, 32% Class I, 16% Class V, 11% Class III, and 2% were Class IV restorations ( $p < 0.0001$  for test of equality of percentages).

Table 3 summarizes the overall data pertaining to dental materials used to restore primary caries by class of restoration. From these findings, it was noteworthy that RBC was the principal material used in all types of restorations, except for Class II restorations. Amalgam was the predominant material used in Class II restorations by dentists from all DPBRN regions apart from those of the SK region. Table 3 also shows that RBC comprised 56% of the total DPBRN restorations placed due to primary caries, while amalgam was used in 38% of these restorations, followed by GI/RMGI in 3%; temporary material in 0.7%; combined metal-ceramic in 0.4%; and all other type of materials (*i.e.* cast gold or other metallic-based material, ceramic or porcelain, and IRBC) in 0.2%. Eighty restorations (1% of the total restorations) were placed using the combination of two restorative materials, for instance amalgam and RBC, or RBC and GI/RMGI.

Table 4 shows the distribution of dental materials by DPBRN region. RBC was the overall material of choice to restore teeth affected by primary caries in the FL/GA, AL/MS and SK regions. However, amalgam comprised 63% of all PDA restorations placed due to caries, whereas 33% of these restorations were placed using RBC and 4% using other materials. The same trend was observed in the MN region, where 56% of all restorations were placed using amalgam, 36% using RBC, and 8% using other materials. Practitioner-investigators from the SK region reported the highest use of RBC (82% of all SK restorations due to caries) when compared to amalgam restorations (6%) and restorations using other materials (12%;  $p < 0.001$  for test of equality of percentages).

A significant difference was found between the types of restorative materials used to restore molar teeth across the DPBRN regions ( $p < 0.0001$ ). In general, 46% of carious molars were restored using amalgam compared to 48% restored using RBC and 5% using other materials ( $p < 0.0001$  for test of equality of percentages). However, RBC was used more frequently in restorations of premolars: 45% of carious premolars were restored with amalgam compared to 49% with RBC and 5% with other materials ( $p < 0.0001$  for test of equality of percentages). Of the anterior restorations, only 2% were restored using amalgam compared to 92% using RBC and 5% using other materials ( $p < 0.0001$  for test of equality of percentages). Dentists from all DPBRN regions often reported using at least one type of base, lining or bonding material. More specifically, 96% of the amalgam and 99% of RBC restorations were preceded by resin-based bonding material, resin-modified glass-ionomer lining, or calcium hydroxide-based cement or liner.

## Discussion

Insights into the main reasons for placement of restorations in previously unrestored tooth surfaces and the selection of restorative materials are necessary to better understand the many aspects of contemporary clinical practice. Primary caries as diagnosed clinically by DPBRN dentists was consistently found to be the main reason for the insertion of initial restorations. Other important reasons for placement of initial restorations included non-cariou cervical lesions and traumatic tooth fracture.

Caries lesions can develop in a variety of anatomic tooth locations and have distinctive aspects of configuration and rate of progression. In the present study, most of the caries lesions for which restorative interventions were required involved the unrestored occlusal surface of permanent molars. In fact, the intricate fissure systems of occlusal surfaces are usually the first sites in the permanent dentition to develop caries.<sup>17, 18</sup> Occlusal surfaces remain a challenging area for caries diagnosis, in part because these lesions appear to initiate on the fissure walls

and can hence be masked by sound superficial tissue. A parallel study verified that DPBRN dentists use conventionally employed techniques, *i.e.* visual-tactile and radiographic examinations, as routine methods for diagnosing primary caries. Both clinical and radiographic assessments seem to be widely used as diagnostic methods for caries by DPBRN dentists, especially among large group practice models such as the PDA and MN regions. In view of the high prevalence of occlusal caries, key clinical questions would be: what is the most appropriate treatment approach for occlusal caries lesions? At what stage of a progressing caries lesion would restorative intervention be recommended? The criteria used by DPBRN dentists for when to place the first restoration, specifically the depth of caries lesions, have been reported elsewhere (V Gordan), unpublished data, (January 2007). Based on the modern concepts of minimally invasive dentistry, management of dental caries should rely on proper detection of pathological alterations and diagnosis, as well as on the consideration of patient risk factors. Evidence of effectiveness of each treatment option is also of great importance.<sup>8, 19</sup> Therefore, this study suggests that reducing variation in diagnosis and treatment of caries or questionable caries on the occlusal surfaces of molars may be an especially rewarding line of research.

Significant progress in dental adhesion over the past few decades has influenced the selection of restorative materials in dental practice. In addition, restrictions on the use of amalgam<sup>20-22</sup>, especially in the SK region, regardless of assurances as to the safety of amalgam alloys, environmental concerns about amalgam, alterations in patterns of dental disease, and increasing esthetic expectations by patients all have contributed to the changes observed in the relative use of materials. In the present study, directly placed resin-based composite was the restorative material selected by the majority of DPBRN dentists, except for those from the PDA and MN regions, where amalgam was the principal material. As expected, composite material was generally used in anterior restorations including Class III, IV and V restorations, and in most Class I restorations. Notably, Class II restorations were mainly placed with amalgam in all DPBRN regions, except in the SK region where the use of this material was severely restricted in 2008 in two of the three Scandinavian countries<sup>20-22</sup>. Other materials used in stress-bearing areas, specifically metal castings and ceramics, comprised only a small percentage of all posterior restorations reported in this study.

Although tooth-colored materials such as resin-based composites have not evolved to the point of totally replacing amalgam, they have become a workable substitute for amalgam in many clinical situations. The estimated past and current use of amalgam and composite materials in Class I and Class II restorations showed a gradual trend toward an increased use of resin-based materials.<sup>23, 24</sup> Class II resin-based composite restorations continue to grow in use and popularity<sup>25</sup>, however the change from amalgam to composite has been more evident for Class I than Class II restorations as demonstrated here. Evidence indicates that for situations in which esthetics are of secondary importance, amalgam remains the most cost-effective direct restorative material.<sup>26</sup> Existing problems with polymerization, contraction stress, and some technique sensitivity may also partially contribute to the continuing use of amalgam on dental restorations of occlusal stress areas. Results from this investigation support the conclusion that amalgam continues to be widely used on these posterior load-bearing restorations. The longevity of all the restorations placed and reported in this study will be further assessed in a long-term DPBRN study.

This study is part of a larger line of research about caries diagnosis and restorative treatment in the DPBRN; a line of research that is ultimately designed to help move the latest scientific evidence into regular clinical practice.<sup>12, 27-29</sup> Decision-making in general dental practice tends to be based on tradition rather than evidence-based knowledge.<sup>30-32</sup> Analyses of the characteristics of DPBRN dentists and their practice characteristics suggest that DPBRN dentists have much in common with dentists at large, while at the same time offering substantial

diversity in terms of the characteristics.<sup>16</sup> Considerable differences were evident in this investigation between individual private practice and large group practice models related to the use of amalgam for restorations other than Class II. Information gathered from evidence-based research is possibly shared and discussed more frequently among dentists from large group practices than in more-isolated solo practices. A separate DPBRN analysis will evaluate if the clinical decisions for placement of restorations on previously unrestored surfaces and the clinical outcomes vary by patient's caries risk, dentist and practice characteristics. A broad representation of dental practice types, treatment philosophies, and patient populations can contribute to education and dissemination of evidence-based information relative to daily clinical practice.

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**Table 1**  
**Number and percentage of DPBRN practitioner-investigators and patients participating in this study and number and percentage of restorations placed by dentists from each DPBRN region**

	AL/MS	FL/GA	MN	PDA	SK	Total
Dentists [N (%)]	63 (27.5)	37 (16.2)	31 (13.5)	51 (22.3)	47 (20.5)	229 (100)
Patients [N (%)]	1506 (25.9)	1022 (17.6)	1084 (18.7)	1233 (21.2)	964 (16.6)	5810 (100)
Restorations [N (%)]	2801 (28.3)	1720 (17.4)	1745 (17.6)	2312 (23.4)	1312 (13.3)	9890 (100)

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**  
**Characteristics of the patients who received restorative treatment by DPBRN region**

Characteristics	AL/MS	FL/GA	MN	PDA	SK	Total
<b>Gender [N (%)]</b>						
Male	688 (45.7)	471 (46.0)	441 (41.2)	604 (49.0)	472 (49.0)	2676 (46.0)
Female	818 (54.3)	551 (54.0)	629 (58.8)	629 (51.0)	492 (51.0)	3119 (54.0)
<b>Race [N (%)]</b>						
White	1169 (79.0)	873 (88.0)	545 (77.0)	1038 (84.3)	919 (97.6)	4544 (84.8)
Black <sup>1</sup>	274 (18.5)	102 (10.3)	106 (15.0)	51 (4.1)	2 (0.2)	535 (10.0)
American Indian <sup>2</sup>	23 (1.5)	3 (0.3)	4 (0.6)	7 (0.6)	1 (0.1)	38 (0.7)
Asian	14 (0.9)	11 (1.1)	45 (6.4)	76 (6.1)	19 (2.0)	165 (3.1)
Native Hawaiian <sup>3</sup>	2 (0.1)	3 (0.3)	0	7 (0.6)	1 (0.1)	13 (0.2)
Other Race	0	0	8 (1.0)	53 (4.3)	0	61 (1.1)
<b>Ethnicity [N (%)]</b>						
Hispanic	23 (1.5)	115 (11.3)	50 (6.6)	79 (6.5)	4 (0.4)	271 (5.0)
Not Hispanic	1465 (98.5)	903 (88.7)	707 (93.4)	1143 (93.5)	960 (99.6)	5178 (95.0)
<b>Insurance [N (%)]</b>						
Yes	1226 (81.7)	677 (66.6)	933 (86.0)	1150 (93.3)	653 (67.9)	4639 (80.0)
No	274 (18.3)	340 (33.4)	151 (14.0)	83 (6.7)	309 (32.1)	1157 (20.0)
<b>Age mean in years (SD)</b>						
	34.1 (18.5)	39.5 (20.2)	34.0 (19.0)	34.7 (16.0)	37.2 (18.3)	35.9 (18.4)

Of the 5,810 patients enrolled in this study, data were collected on gender from 5,795 patients; 5,356 on race; 5,449 on ethnicity; and 5,796 on insurance coverage.

<sup>1</sup> Black or African-American;

<sup>2</sup> American Indian or Alaska Native;

<sup>3</sup> Native Hawaiian or Other Pacific Islander. Percentages are within columns for each patient characteristic.

**Table 3**  
**Distribution of the dental materials used to restore primary caries by restoration class type**

Restoration Class	Amalgam	RBC	IRBC	GI/RMGI	Ceramic	Cast Gold	Metal	Temporary	Multiple	Total
<b>Class I</b> [N (%)]	938 (36.3)	1569 (60.7)	2 (0.08)	51 (2.0)	0	0	3 (0.1)	4 (0.15)	18 (0.7)	2585 (100)
<b>Class II</b> [N (%)]	1780 (56.5)	1189 (37.7)	1 (0.03)	67 (2.1)	5 (0.16)	5 (0.16)	22 (0.7)	43 (1.4)	39 (1.3)	3151 (100)
<b>Class III</b> [N (%)]	24 (2.6)	856 (92.4)	0	35 (3.8)	0	0	3 (0.3)	3 (0.3)	5 (0.6)	926 (100)
<b>Class IV</b> [N (%)]	2 (1.4)	132 (93.6)	0	5 (3.5)	1 (0.7)	0	0	1 (0.7)	0	141 (100)
<b>Class V</b> [N (%)]	374 (28)	844 (63.0)	2 (0.2)	87 (6.5)	0	2 (0.2)	5 (0.4)	5 (0.4)	18 (1.3)	1337 (100)
<b>Total</b> [N (%)]	3118 (38.0)	4590 (56.4)	5 (0.1)	245 (3.0)	6 (0.1)	7 (0.1)	33 (0.4)	56 (0.7)	80 (1.0)	8140 (100)

Directly placed resin-based composite: RBC; indirectly placed resin-based composite: IRBC; glass-ionomer or resin-modified glass-ionomer: GI/ RMGI; ceramic: ceramic or porcelain; cast gold: cast gold or other metallic-based material; metal: combined metal-ceramic material; temporary: temporary restorative material; multiple: combination of multiple materials. Of the 8,351 restorations inserted due to primary caries, a total of 8,140 restorations were recorded with data on the use of dental materials by restoration class. Percentages are within rows for each restoration class.

**Table 4**  
**Dental materials used to restore primary caries by DPBRN region**

DPBRN Regions	Amalgam	RBC	Others	Total
AL/MS [N (%)]	676 (28.3)	1580 (66.2)	130 (5.5)	2386 (100)
FL/GA [N (%)]	289 (21.8)	988 (74.6)	48 (3.6)	1325 (100)
MN [N (%)]	842 (56.3)	532 (35.6)	121 (8.1)	1495 (100)
PDA [N (%)]	1285 (63.2)	681 (33.5)	68 (3.3)	2034 (100)
SK [N (%)]	60 (5.9)	832 (82.0)	123 (12.1)	1015 (100)
<b>Total [N (%)]</b>	<b>3152 (38.0)</b>	<b>4613 (56.0)</b>	<b>490 (6.0)</b>	<b>8255 (100)</b>

Directly placed resin-based composite; RBC: others: indirectly placed resin-based composite, glass ionomer or resin-modified glass ionomer, ceramic or porcelain, cast gold or other metallic-based material, combined metal-ceramic material or a temporary restorative material. Of the 8,351 restorations inserted due to primary caries, a total of 8,255 restorations were recorded with data on the use of dental materials. Percentages are within rows for each DPBRN region.