# Restorative Treatments Received by Children Covered by a Universal, Publicly Financed, Dental Insurance Plan

**Amid Ismail, BDS, MPH, DrPH; Jean-Marc Brodeur, DDS, MSc, PhD; Pierre Gagnon, DDS, MPH, MS; Martin Payette, DDS; Daniel Picard, DMD, MSc; Talia Hamalian, DDS; Marie Olivier, DDS, MSc**

Abstract

***Objectives:*** *This study sought to identify risk markers associated with the provision of new restorations in children and to investigate whether the carious status of a tooth surface is associated with the restorative decisions of dentists.* ***Methods:*** *A total of 911 schoolchildren in grades one, two, and three were randomly selected from the island of Montreal, Quebec, Canada. Dental examinations were carried out in 1990, 1991, and 1992. Tooth surfaces of first permanent molars were classified as sound, noncavitated, and cavitated. The carious status of a tooth was matched with restorative decisions reported to the insurance board.* ***Results:*** *The presence of a carious cavity was a strong risk marker for placement of new restorations (odds ratios ≥4.11). After one year, less than 2 percent of sound tooth surfaces of first permanent molars were restored and about 21 percent of noncavitated tooth surfaces were restored. When new class I restorations placed in maxillary first permanent molars within 3–6 months after the baseline examination were evaluated, we found that between 73 percent and 86 percent of these new restorations were placed in sound or noncavitated tooth surfaces. A similar trend also was observed in mandibular first permanent molars. Poor agreement between epidemiologic diagnosis and restorative decisions was found. The restorative profile of dentists was a significant risk marker for placement of new restorations.* ***Conclusion:*** *The majority of new restorations in first permanent molars were placed in sound and noncavitated tooth surfaces because of the ubiquitous prevalence of these tooth surfaces and the validity problems of current caries diagnosis methods. [J Public Health Dent 1997;57(1):11-18]*

*Key Words: dental caries diagnosis, restorative decisions, treatment needs.*

Restorative dentistry remains the major dental service provided by dentists. During the last two decades, the appropriateness and rationale for restorative care have come under scrutiny (1-9). One study that generated a great deal of discussion of the topic of appropriateness of restorative care was conducted in 1978 by the Dental Health Services Research Unit of the University of Dundee, Scotland (1-8). The restorative treatments received by a sample of 720 adults, who were examined in an epidemiologic survey, were followed using the database of the General Dental Service (GDS). One year after the epidemiologic examinations, twice as many tooth surfaces were restored than had been predicted by the survey examiners; after three years, this difference had risen to 3.5 times (7). Despite this difference, 59 percent of the restorative treatment needs identified by the baseline examiners remained unmet by the end of the first year of the study, and 46 percent remained unmet by the end of the third year (1).

While some of the discrepancy between the treatment needs estimated from epidemiologic data and the actual treatments provided by dentists could be due to the use of epidemiologic criteria that diagnosed caries only when cavitation was present and without the use of radiographs, the disconcordance was too high to be explained by this reason alone. There is evidence that some dentists fill teeth at the precavitation stage or even at the "sticking" stage (10-12).

As in adults, studies with children that have evaluated the validity of restorative treatment needs estimated in epidemiologic studies found poor agreement with actual treatment provided by dentists. Nuttall and Davies (13) found that during one year of follow-up of 12-year-old children, twice as many tooth surfaces were filled compared with the baseline estimates and about 83 percent of new restorations were placed in sound tooth surfaces. Also, about half of the tooth surfaces defined as visually cavitated during the epidemiologic examination were not restored or extracted. This study confirmed the findings of previous studies (14-15).

The research conducted at the Department of Operative Dentistry at the University of North Carolina (16-18) showed that clinical status is but one of the factors used by dentists when deciding to restore. Investigators in these studies found that about 11 percent of dentists examining sound teeth recommended restorative treatment (18). For restored teeth with no secondary or primary caries, 35 percent of dentists recommended replacements. If all the dentists' treatment recommendations were followed, about twice as many restorations could have been provided than that predicted based upon the epidemiologic examination.

The purpose of this longitudinal study is to identify the risk markers associated with the provision of restorations in children covered by a universal, publicly financed, dental insurance program and to investigate

Send correspondence and reprint requests to Dr. Ismail, Faculty of Dentistry, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada. Internet: ismaildl@is.dal.ca. Dr. Brodeur is affiliated with the Department de Médecine Sociale et Préventive, Université de Montréal. Dr. Gagnon is with the Faculté de Médecine Dentaire, Université Laval, Ste-Foy, Quebec, Canada. Drs. Payette, Picard, and Olivier are at the Hôpital St-Luc, Montréal. Dr. Hamalian is in private practice, Montréal. This investigation is supported by NHRDP, grant number 6605-1340-CD from Health and Welfare, Canada. Manuscript received: 3/7/95; returned to authors for revision: 6/1/95; accepted for publication: 2/19/96.

whether the clinical carious status of a tooth surface is associated with the decision of a private dentist to restore it. In this analysis, the restorative treatments reported by dentists to the insurance board were correlated with the carious status of tooth surfaces, as determined in a detailed clinical examination.

## Methods

**The Quebec's Children's Dental Program.** In Quebec, the children's dental insurance program, during the period of follow-up in this longitudinal study, covered diagnostic, restorative, endodontic, and minor surgical services for all children between birth and 12 years of age. Preventive care is provided by the local health units to all children in elementary schools. Pit and fissure sealants were not covered.

In 1981–82, it was reported that on average 2.87 restorations per child were charged to the insurance board (Regie de l'assurance-maladie du Quebec [RAMQ]), a rate twice that reported by other provinces (19). In 1992, the Quebec government spent about $64 million to pay for the dental care of children covered by the dental insurance program. Dental examinations and restorative treatments cost about 41 and 44 percent, respectively, of the total dental care cost in that year.

**Study Cohort.** A representative sample of schoolchildren in grades one through three on the island of Montreal was selected using a stratified random sampling method of classrooms in elementary schools. A total of 19 out of the 20 selected schools agreed to participate. Out of the 1,428 students sampled, the parents of 1,003 (70.2%) consented to participate in the study in 1990, 1991, and 1992, and allow access to the dental insurance records of their children. A total of 911 students were examined in 1990. Out of those, 816 were examined in 1991. Finally, 733 students of the original sample were examined in 1992. About 86 percent of the students were French speaking and 51 percent were males.

**Examination Criteria and Clinical Examination.** The dental examination in this study was designed to provide detailed information on the status of each tooth surface. The examiner dried and cleaned each tooth prior to inspection. The examiners were extensively trained to conduct a thorough visual examination and use dental explorers to check the surface texture of a carious tooth surface, but not to penetrate it.

A full description of the examination criteria was presented in a previous paper (20). To determine the clinical status of each tooth surface that could receive a restoration during this longitudinal study, a new diagnostic criteria system was developed that differentiated between sound, noncavitated (stained, questionable, or early caries), and cavitated caries lesions in pits and fissures. The new scoring system was developed using published caries diagnostic criteria and real-life descriptions of clinical status of carious lesions detected in about 200 children who only participated in the pilot study. Development and testing of the criteria and training of examiners took place during the first year of the project. On smooth tooth surfaces, the new diagnostic criteria differentiated between incipient caries and cavitated carious lesions.

Noncavitated carious pits or fissures were diagnosed as follows: After cleaning and drying the tooth, the examiner visually checked whether the tooth surface was cavitated (loss of enamel) or not. If not, and if the pits or fissures were colored light or dark brown at their base and/or a white change (demineralization) in sides of the pits or fissures was detected, then the area was scored as noncavitated. Stained pits and fissures also were coded in this category.

A "cavity" was defined as any loss of tissue beyond the boundaries of developmental pits and fissures on occlusal surfaces. Cavities were classified into arrested lesions that did not have softened floors or sides that could be detected using an explorer with gentle pressure; or active cavitated lesions that contained demineralized dentin (usually light brown in color) and had soft texture upon exploring with gentle pressure.

The noncavitated carious category represented a unique status that was different from the so-called "incipient carious lesion." Noncavitated carious lesions were discolored (light or dark brown). Therefore, there was little chance of disappearance of those lesions. In fact, out of the 346 noncavitated carious pits and fissures in maxillary first permanent molars, only 18 (5.2%) were diagnosed as sound after one year. (The examiners did not have access to the status of the tooth at baseline.)

Two dentists (a private dentist and a public health dentist) were trained to follow the protocol of the project. A senior examiner (a pediatric dentist) also was trained to conduct random checks of the two main examiners during the examination periods. The two examiners' reliability in applying the criteria was measured throughout the data collection periods. The interexaminer reliability (kappa coefficients) for pits and fissures was higher than 0.80 and for smooth surfaces was 0.74 or higher. The intraexaminer reliability coefficient was higher than 0.90 for both examiners. For pits and fissures, examiner number "1" consistently detected, during repeat examinations, 95 percent of the sound tooth surfaces, 83.7 percent of the noncavitated carious tooth surfaces, and 100.0 percent of the cavitated tooth surfaces. Examiner "2" consistently detected 94.5 percent, 69.8 percent, and 87.5 percent of the sound, noncavitated, and cavitated carious tooth surfaces, respectively.

In this analysis only data from the maxillary and mandibular first permanent molars are presented. Each pit and fissure area was scored separately from the smooth tooth surface area and the mesial and distal pits of the occlusal surfaces of the maxillary first permanent molars also were scored separately. The total number of potential tooth surfaces scored in the maxillary first permanent molars was 10,262 (733 children with two teeth and each tooth with seven tooth surfaces) and there were 8,796 separate possible tooth surfaces in the mandibular first permanent molars.

**Validity of the New Caries Diagnostic System.** The validity of the diagnostic criteria was tested in two separate studies conducted at the Dental Clinic of Dalhousie University, Halifax, Nova Scotia. In the first study, the underestimation of caries diagnosis that could result from not taking radiographs was evaluated (21). A total of 96 consecutive patients seen at the Dalhousie University Dental Clinic were concurrently examined by two dentists. The dentists were trained to follow a clinical examination protocol that classified each pit and fissure of the examined teeth into sound, noncavitated, and cavitated status. After several weeks, the bitewing radio-

graphs of the examined teeth were scored concurrently by two dentists using the method described by de Vries et al. (22). The clinical examiners diagnosed a total of 45 noncavitated pit and fissures in the 96 patients. Only 2.2 percent of the radiographic images of noncavitated carious tooth surfaces showed evidence of caries in dentin. Of the clinically sound pits and fissures, only 1.6 percent showed evidence of enamel caries and none showed evidence of dentinal caries.

In a second study, nine young adults received the same examinations performed in the first study (23). However, in this study, the dentists "biopsied" the carious lesions and placed either a sealant, sealant-restoration, or a conventional amalgam restoration, depending on the size of the affected area. The biopsy was carried out using a small round bur and only the affected area was removed. The dentists removed the affected and stained tissue with extreme care and stopped frequently to test the carious status of the remaining dental tissue and record their findings. Out of 19 noncavitated carious lesions diagnosed using the criteria of the longitudinal study described here, five (26.3%) were found to contain only staining, 10 (52.6%) were diagnosed with caries in enamel, and four (21.1%) had dentinal caries. Overall, 15 out of 18 (83.3%) noncavitated carious pits and fissures either were stained or had only caries in enamel.

**Questionnaire.** In addition to the clinical examination, data abstracted from a self-administered questionnaire that was mailed before the baseline examination are used in this study. The questionnaire asked about the education status of the parents, date of birth of the child, sex, and the use of out-of-pocket money for dental care.

**Dental Insurance Data.** The insurance board database was used to abstract information about all restorations received by each child in the cohort from birth or the date when a child joined the dental insurance plan. The data included information on tooth type, restored surfaces, restoration class, date of restoration, dentists' "dummy" identification codes, dentist year of graduation, and dentist sex. The unique RAMQ number of each child was used to link the epidemiologic and the RAMQ treatment databases. Also, data were abstracted from each dentist's claims profile. The dentists' data included information on the number of diagnostic, preventive, restorative, and endodontic services provided for all of their patients (not only those who were selected in this study) and reported to the insurance board. This information was used to develop a profile for each dentist. In this analysis, dentists' sex, year of graduation, and proportion of restorative services reported by a dentist for all children seen by him or her (not only those in the cohort) were used as indicators.

**Data Analysis.** Three- and six-month windows after the examinations in 1990 and 1991 were chosen for analysis of the restorative decisions of dentists (RAMQ data) because during these two short time periods it is highly unlikely that sound tooth surfaces could become carious or noncavitated carious lesions could progress significantly. Additionally, using the three- and six-month data allows for replication of the findings. Replication is important to confirm the findings because of the small number of new restorations placed during the three-month period following the baseline examinations.

Only children who were examined in 1990, 1991, and 1992 were included in this analysis ($n$=733). During the three months following the 1990 and 1991 examinations, the children visited 148 and 232 dentists, respectively; after six months, 232 and 233 dentists were visited, respectively. The 1992 data were used in this analysis only to exclude teeth that had reversals or recording errors. Tooth surfaces with the following changes in status during the three examinations were excluded: any change from noncavitated to sound status, any change from cavitated to sound or noncavitated or sealed status, any change from filled status to sound or sealed or noncavitated status (without any filling found in a surface). In addition, all sealed and filled tooth surfaces found during the 1990 examination were excluded from this analysis because the objective was to evaluate the placement decisions of new restorations.

All epidemiologic data were entered in a database custom-written in FOXBASE+/Mac® and checked twice for accuracy. The unit of analysis used in this study was the tooth or tooth surface. FORTRAN programs were written to create different data sets for tooth surface-specific analyses. Matching between the insurance board data set, dentist file, and clinical examination was carried out using the unique identification number of the children used in all files. When the unit of analysis was the tooth rather than a tooth surface, the worst condition found on the tooth was used to indicate the caries status of the tooth.

All bivariate analyses were carried out using SPSS-PC. Kappa coefficients were computed to estimate the degree of correlation between restorative treatment needs estimated from the epidemiologic examination and the actual restorative treatment provided by the private dentists. In determining treatment needs, two estimates were computed: (1) all noncavitated pits and fissures and cavitated carious tooth surfaces were recommended for restoration (NCCA option), and (2) only cavitated carious tooth surfaces were restored (CA option).

In the multivariate analysis, children who visited a dentist during the follow-up periods were included in the analysis. For children with a dental visit, the characteristics of the dentist who provided a new restoration were matched only with the newly restored tooth surfaces. Other tooth surfaces were matched with the characteristic of the dentist who provided the annual dental check-up examination, if that dentist differed from the one who placed a new restoration. For children with dental visits but with no regular dental recall examination or restorative visits during the follow-up periods, the characteristics of the dentist who provided the highest number of dental services to the child were used in the multivariate analysis.

The General Estimating Equations approach (GEE) was used to estimate odds ratios for different indicators of new restorations (24,25). In the GEE model 10 tooth surfaces per child formed a cluster. The occlusal and buccal surfaces of the mandibular first permanent molars and the two occlusal pits and lingual fissures of the maxillary first permanent molars were included. These tooth surfaces were chosen because they had the highest restorative activity among all other surfaces in the mouth. In addition, since pits and fissures represented the most caries active sites in the mouth,

the data set used for the GEE analysis did not include teeth where class II (MO or DO) restorations were placed in first permanent molars during any of the follow-up periods. The multivariate analysis was conducted using SPIDA (Statistical Packages for Interactive Data Analysis, Statistical Laboratory, Macquarie University, New South Wales, Australia). Population weights were computed and used in the analysis to adjust for unequal response rates among the schools.

## Results

Table 1 presents the number of students examined between 1990 and 1992. Table 2 presents the numbers and proportions of tooth surfaces that were excluded because of reversals. Overall, only 0.4 and 0.3 percent of maxillary and mandibular first permanent molars were excluded, respectively. Of the noncavitated and cavi-

**TABLE 1**
**Number of Children Examined by Grade and Year of Follow-up**

| | Year of Follow-up | | |
|---|---|---|---|
| Grade | 1990 | 1991 | 1992 |
| 1 | 296 | | |
| 2 | 297 | 256 | |
| 3 | 318 | 273 | 230 |
| 4 | | 287 | 246 |
| 5 | | | 257 |
| Total | 911 | 816 | 733 |

**TABLE 2**
**Number and Percent of First Permanent Molar Tooth Surfaces Excluded Because of Reversals* or Recording Errors during Follow-up Periods**

| Tooth Status | Total # Tooth Surfaces in 1990 | Number (%) Excluded |
|---|---|---|
| Mandibular first permanent molars (16,26)† | | |
| Sound | 8,136 | 0 |
| Noncavitated | 346 | 29 (8.4) |
| Cavitated | 73 | 6 (8.2) |
| Mandibular first permanent molars (36,46)† | | |
| Sound | 7,070 | 0 |
| Noncavitated | 149 | 13 (8.7) |
| Cavitated | 79 | 8 (10.1) |

*Defined as any change in status of tooth that is inconsistent with disease progression. E.g., a cavitated carious tooth surface in 1990 diagnosed in 1991 or 1992 as sound. Or, a cavitated carious tooth surface in 1990 diagnosed in 1991 or 1992 as noncavitated.
†Seven separate tooth surfaces of the maxillary first permanent molars were scored, resulting in a total of 10,262 tooth surfaces for both maxillary teeth. The mandibular first permanent molars were divided into six tooth surfaces each resulting in a total of 8,796 tooth surfaces for both teeth.

**TABLE 3**
**Percent of Children with Any Dental Visit and Those with a Restorative Visit 3 and 6 Months after the 1990 and 1991 Examinations**

| | Months after 1990 | | Months after 1991 | |
|---|---|---|---|---|
| Visit | 3 | 6 | 3 | 6 |
| Dental | 30.0 | 54.6 | 33.3 | 57.2 |
| Restorative | 11.5 | 20.6 | 11.6 | 19.8 |

**TABLE 4**
**Prevalence of Sound, Noncavitated, and Cavitated Carious Tooth Surfaces in First Permanent Molars in the 1990 and 1991 Examinations and Percent of Restored Tooth Surfaces after One-year Follow-up***

| Tooth Type | 1990 | 1991 |
|---|---|---|
| Maxillary first permanent molars | | |
| Sound | | |
| Prevalence | 8,136 | 7,483 |
| Number restored after one year† | 153 | 95 |
| Percent restored | 1.9 | 1.3 |
| Noncavitated pits and fissure | | |
| Prevalence | 317 | 880 |
| Number restored after one year | 68 | 122 |
| Percent restored | 21.5 | 13.9 |
| Cavitated pits and fissure | | |
| Prevalence | 67 | 82 |
| Number restored after one year | 25 | 30 |
| Percent restored | 37.3 | 36.6 |
| Mandibular first permanent molars | | |
| Sound | | |
| Prevalence | 7,070 | 6,746 |
| Number restored after one year | 119 | 73 |
| Percent restored | 1.7 | 1.1 |
| Noncavitated pits and fissures | | |
| Prevalence | 136 | 409 |
| Number restored after one year | 28 | 53 |
| Percent restored | 20.6 | 13.0 |
| Cavitated pits and fissure | | |
| Prevalence | 71 | 85 |
| Number restored after one year | 23 | 44 |
| Percent restored | 32.4 | 51.8 |

*Percent of pit and fissure tooth surfaces restored including those restored as part of a restoration that involved mesial or distal tooth surfaces. Each maxillary first permanent molar contributed seven tooth surfaces and each mandibular first permanent molar contributed six tooth surfaces.
†Based upon the findings of the epidemiologic examinations.

tated maxillary and mandibular first permanent molars, less than 10 percent of the tooth surfaces were excluded from the correlation analyses (Table 2).

No statistically significant differences were found in age, sex, and the highest education status of the parents between the fully examined children and those who were not examined in 1991 or 1992. However, children who were not available for examination after the 1990 examination attended schools located in areas with a lower socioeconomic index (SEI) than those of the participants. Overall, the children from low SEI areas were significantly more likely to receive restorations than children from high SEI areas (13.5% vs 7.9%, respectively). They also were less likely to receive sealants than the other children (17.1% of the children in the high SEI areas received sealants vs 5.9% of the children in low SEI areas) (26). Because of the higher probability of restoring teeth in children who were not followed, we conclude that the findings reported in this paper underestimate the true association between caries status and the decision to place a restoration.

Of the 733 children in the cohort, 220 (30.0%) and 400 (54.6%) children visited a dentist during the three and six months following the baseline examination in 1990 (Table 3). A similar trend is observed after the 1991 examination. About 12 percent and 21 percent received restorative services during the follow-up periods (Table 3).

Table 4 presents the number of sound, noncavitated, and cavitated tooth surfaces in the maxillary and mandibular first permanent molars in 1990 and 1991. While the number of cavitated carious tooth surfaces increased from 138 to 167 within one year, there was a higher increase in the number of noncavitated carious tooth surfaces (from 453 to 1,289). Cavitated tooth surfaces were significantly more likely to be restored than noncavitated ones ($P<.01$; clustering effects of disease within a mouth were accounted for) for all teeth and time periods except for mandibular first permanent molars within a year after the baseline examination in 1990. Both noncavitated and cavitated tooth surfaces were significantly more likely to be restored compared with sound tooth surfaces ($P<.001$).

Table 5 presents the number of new restorations reported to the insurance board. Using the worst condition of a tooth to classify its status into sound, noncavitated, or cavitated carious status, almost one-half of the new restorations were placed in sound maxillary first permanent molars after the 1990 baseline examination. For mandibular first permanent molars, 35.4 and 48.6 percent of the new restorations were placed in sound teeth, three and six months after the baseline examination in 1990, respectively. Overall, between 52 percent and 85 percent of the new restorations in first permanent molars were placed in sound or noncavitated pits and fissures within six months after the base-

**TABLE 5**
**Number and Percent (Weighted) of New Restorations Placed by Tooth Type***

| Tooth Type by Follow-up Period | Number of New Restorations | Caries Status at Baseline† | | | |
|---|---|---|---|---|---|
| | | Sound | NC | CA | U |
| Maxillary first permanent molars | | | | | |
| Months after 1990 examination: | | | | | |
| 3 | 36 | 51.8 | 21.4 | 26.8 | |
| 6 | 57 | 48.0 | 30.5 | 20.1 | 1.4 |
| Months after 1991 examination: | | | | | |
| 3 | 36 | 20.5 | 65.3 | 14.2 | |
| 6 | 54 | 23.7 | 55.0 | 17.4 | 3.9 |
| Mandibular first permanent molar | | | | | |
| Months after 1990 examination: | | | | | |
| 3 | 30 | 35.4 | 53.6 | 11.0 | |
| 6 | 60 | 48.6 | 36.5 | 13.7 | 1.2 |
| Months after 1991 examination: | | | | | |
| 3 | 30 | 16.9 | 35.1 | 48.0 | |
| 6 | 56 | 22.5 | 34.3 | 39.5 | 3.7 |

*All tooth surfaces included and reversals excluded.
†Percent of restorations placed in tooth surfaces with NC=noncavitated caries and incipient caries on smooth surfaces, CA=cavitated caries, or were U=unerupted at baseline (1990 or 1991 examinations).

**TABLE 6**
**Number of New Restorations by Baseline Caries Status of the Occlusal (O), Lingual (L) Fissures, and Buccal (B) Pits of First Permanent Molars by Time in Months after 1990 and 1991 Examinations***

| | Months after Baseline Examination | | | |
|---|---|---|---|---|
| | 1990 | | 1991 | |
| Caries Status in 1990 | 3 | 6 | 3 | 6 |
| 16, 26 (O, L, OL) | | | | |
| Sound | 16 | 25 | 6 | 10 |
| Noncavitated caries | 7 | 16 | 22 | 27 |
| Cavitated caries | 9 | 11 | 4 | 9 |
| Total | 32 | 52 | 32 | 46 |
| 36, 46 (O, B, OB) | | | | |
| Sound | 9 | 26 | 3 | 7 |
| Noncavitated caries | 15 | 20 | 7 | 12 |
| Cavitated caries | 3 | 7 | 12 | 15 |
| Total | 27 | 53 | 22 | 36 |

*Reversals excluded. All teeth with newly placed restorations on mesial or distal surfaces were excluded.

line examination. After the 1991 examination, more new restorations were placed in cavitated tooth surfaces of the mandibular than maxillary first permanent molars.

Table 6 repeats the analysis presented in Table 5, but excludes all teeth with mesial and distal restorations placed during the follow-up periods. Again, repeating the findings of Table 5, the majority of the restorations were placed in sound tooth surfaces after the 1990 examination. After the 1991 examination, in the maxillary first permanent molars, 68.8 percent (22 out of 32) and 58.7 percent (27 out of 46) of the new restorations were placed in noncavitated pits and fissures after three and six months, respectively. By contrast, in the mandibular first permanent molars, 54.5 percent (12 out of 22) and 41.7 percent (15 out of 36) of the new restorations were placed in cavitated carious pits and fissures.

Table 7 presents a comparison between the number of recommended restorations based on the epidemiologic examinations and the number of restorations actually provided by the dentists during each of the follow-up periods. If all noncavitated and cavitated carious teeth are recommended for restorations, then the dentists provided from about 1.7 to 4 times fewer restorations than recommended. If only cavitated carious teeth were recommended for restorations, then the dentists provided between 1.3 to 2.4 times more restorations than the number of restorations recommended based only upon the findings from the epidemiologic examinations. Except for the new restorations placed in mandibular first permanent molars three months after the 1991 examination (kappa=0.48), there was poor agreement (kappa lower than 0.40) between recommended restorative treatments and the treatments actually provided by the dentists. Even if only cavitated carious teeth were recommended for restoration, it was found that about one-third

**TABLE 7**
**Number of Maxillary and Mandibular First Permanent Molars Recommended for Restoration and Number of Restorations Provided by Dentists***

| Months after Examination | NCCA Option† | CA Option† | Provided† |
|---|---|---|---|
| Maxillary first permanent molar | | | |
| 3 months after 1990 | 62 | 21 | 36 |
| 3 months after 1991 | 135 | 15 | 36 |
| 6 months after 1990 | 90 | 23 | 57 |
| 6 months after 1991 | 213 | 23 | 54 |
| Mandibular first permanent molar | | | |
| 3 months after 1990 | 63 | 23 | 30 |
| 3 months after 1991 | 113 | 20 | 30 |
| 6 months after 1990 | 95 | 33 | 60 |
| 6 months after 1991 | 195 | 35 | 56 |

*Reversals excluded.
†In the NCCA option all noncavitated and cavitated carious teeth in children with dental visits are recommended for restorations. In the CA option, only cavitated carious teeth are recommended for restorations. The number of restorations provided by dentists was computed from the dental insurance board database.

**TABLE 8**
**Odds Ratios, Estimated Using the General Estimating Equations Logistic Link Function, of Risk Markers of New Restorations in Occlusal, Buccal, and Lingual Pits and Fissures of Permanent First Molars**

| | Odds Ratios (95% CI) | | | |
|---|---|---|---|---|
| | Months after 1990 Examination | | Months after 1991 Examination | |
| Risk Markers | 3 | 6 | 3 | 6 |
| Age of child in 1990 | 1.30 (0.90, 1.87) | 1.24 (0.91, 1.69) | 0.78 (0.47, 1.29) | 0.80 (0.53, 1.20) |
| School area socioeconomic index | 0.97 (0.94, 1.00)† | 0.99 (0.96, 1.01) | 1.01 (0.98, 1.03) | 0.99 (0.96, 1.02) |
| Highest education of parents | 0.66 (0.41, 1.06) | 0.84 (0.60, 1.18) | 1.24 (0.82, 1.87) | 0.93 (0.63, 1.36) |
| Caries-free status | 0.09 (0.01, 0.71)† | 0.22 (0.08, 0.66)¶ | 0.66 (0.11, 1.07) | 0.63 (0.14, 2.75) |
| Year of graduation of dentist | 0.98 (0.91, 1.05) | 0.99 (0.95, 1.03) | 1.01 (0.95, 1.076) | 0.98 (0.93, 1.04) |
| % restorative services in insurance database* | 1.04 (1.00, 1.09)† | 1.05 (1.01, 1.08)¶ | 1.07 (1.04, 1.11)¶ | 1.08 (1.05, 1.11)¶ |
| Cavitated in 1990 | 4.11 (1.52, 11.18)‡ | 4.07 (1.71, 9.68)¶ | 16.65 (6.88, 40.30)¶ | 14.94 (7.35, 30.37)¶ |
| # of checkup dental visits in preceeding 4 years | 0.94 (0.77, 1.14) | 1.03 (0.88, 1.20) | 0.98 (0.77, 1.24) | 0.97 (0.81, 1.18) |

*The average of this variable is 25% and minimum and maximum are about 0.0% and 84.0%, respectively. If the difference in restorative profiles between two dentists was 10%, e.g., then the odds ratio for this factor becomes 1.52.
†$P<.05$.
‡$P<.01$.
¶$P\leq.001$.

to one-half of the recommended one-surface restorations and about two-thirds of the two-surface restorations were not provided six months following the baseline examinations in children with a dental visit.

Children with caries-free status were significantly less likely to receive new restorations after the 1990 examination, but not after the 1991 examination (Table 8). The two consistent factors associated with placement of restorations were the presence of a cavitated carious lesion in the pits and fissures of first permanent molars and the restorative profile of dentists who placed restorations. The restorative profile was defined as the percent of restorative services provided by the dentists out of all dental services for all children ever seen by the dentist according to the insurance board data (Table 8). Cavitation increased the odds of receiving a new restoration between four and 15 times. The dentists on average had a restorative service profile of 25 percent, with a range of 0–84 percent. Consequently, a slight change in the restorative profiles could result in an increase in the odds of placement of a new restoration. For example, if dentist "A" had a restorative profile of 35 percent and dentist "B" had a restorative profile of 20 percent, then the odds ratio of a new restoration could increase to 1.88, representing an 88 percent higher probability of placement of a new restoration.

## Discussion

The findings of this study are limited by the accuracy of the reports of restorative treatment provided in dental offices to the children selected in this study filed by the dentists to the insurance board (RAMQ). We found in our preliminary evaluation of the insurance database, before the study was launched, that all dental procedures were reported by dentists to the insurance board and, therefore, we expect an almost complete reporting of the restorative treatments provided to the children in the study. No extra billing of covered dental services is allowed in the dental insurance program in Quebec and private dental insurance plans do not cover services covered by the publicly financed dental insurance plan.

The findings reported here replicate some of the findings of the Scottish (13) studies discussed earlier. However, the findings of this study shed very important light on the previous findings. In the Scottish studies (1-8) dental caries was diagnosed when cavitation was present. Consequently, it was concluded that many "unnecessary" restorations were placed. Based upon the findings of this analysis and considering the conclusions of the pilot studies, which showed that about 17 percent of the noncavitated carious lesions involved dentin, we cannot conclude that such teeth were restored unnecessarily. Moreover, if noncavitated carious lesions were diagnosed in the Scottish studies (1-8), the findings might have shown that the number of restorations estimated by the epidemiologic examiners either matched or underestimated the number of restorations provided by private dentists, as was found in this study (Table 7).

As to the restoration of sound tooth surfaces, the poor specificity of the current diagnostic methods of dental caries is perhaps the culprit. In an era when sound tooth surfaces and caries-free children are ubiquitous, even a minor error in diagnosing dental caries could have a significant impact on the number of sound tooth surfaces restored unnecessarily. This study does not support the claim that unnecessary restorations were placed intentionally by dentists; rather, the findings indicate that there is a problem with the current diagnostic systems of dental caries and restorative decision principles used in dental practices.

A series of recent studies reported by Weerheijm and coworkers (27-28) showed that there is a problem in the diagnosis of "hidden caries" in pits and fissures. It was estimated that in 12-year-old children, 15 percent of clinically sound occlusal surfaces have radiographic evidence of dentin caries and 31.6 percent of clinically carious occlusal surfaces (in dentin) were found sound radiographically. These findings could explain the discrepancies between the clinical examination and actual treatment provided by the dentists who had access to radiographs. However, what cannot be explained is the proportion of teeth that were identified for restoration, but were not restored by the dentists. This discrepancy suggests that the current caries diagnostic methods have unacceptably low accuracy (29-31). Other patient factors (such as education, scheduling, time commitment of parents) also might play a role in explaining why carious lesions were not restored.

The other potential contentious issue in this study may be the new classification system of dental caries. It is important to remember here that the study was designed to investigate the reasons for provision of restorative treatment. The criteria were developed to provide a picture of tooth status that could allow the investigators to determine how the appearance and texture of tooth surfaces (discolored, cavitated) influenced the subsequent restorative decisions of dentists. The inter- and intraexaminer reliability of the two examiners ranged between good to very good.

Given that the costs of restorations are usually over 40 percent of the total cost of dental insurance of children in Quebec and other Canadian provinces with universal dental insurance programs (data available from the authors), there is a need to update those programs to incorporate guidelines for restorative decision making. These programs also should cover new conservative procedures such as sealants and sealed restorations. The need for conventional restorations in children has diminished significantly since the dental insurance programs in Canada were developed in the 1970s. The findings of this study support a cautious approach in restorative management of dental caries in children. Dentists should wait, watch, and attempt to remineralize and arrest rather than restore, especially when early carious lesions are detected. Most importantly, dental insurance programs and dental fee guides should adequately compensate dentists for their time in promotion of oral heath through the use of remineralization, sealants, and fluorides.

The finding that the restorative practice patterns of dentists is an important marker for placement of new restorations is troubling and is not new. In this study, new graduates and female dentists had significantly higher restorative profiles. While this difference might be dependent on the type of patients seen by the dentists, there is also evidence from other Canadian studies of variation in restorative decisions of graduates from different dental schools (11), indicating that

patient factors alone cannot explain the differences seen in restorative profiles of the dentists involved in this study (the range was between 0% and 84%). McKnight-Hanes and others (32) found that dentists in the United States who are in the 60+-year-old age category were more likely to recommend composite restorative resins than younger dentists, and dentists in the 40–49-year-old age group were more likely to recommend stainless steel crowns compared with other age groups. Henke and Epstein (33) found that characteristics of the physicians managing patients with rheumatoid arthritis are more important than patient characteristics or practice incentives.

Epidemiologic research has a direct impact on policy making, whether the findings are welcomed or not. The findings of this study show there is a need for developing a new caries diagnostic system with very high specificity. In addition, restorative practice guidelines should be disseminated to promote tooth preservative management of dental caries. Dental insurance and dental fee guides should be redesigned to promote health as well as treatment.

## References


1. Elderton RJ. Longitudinal study of dental treatment in the General Dental Service in Scotland. Br Dent J 1983;155:91-6.
2. Elderton RJ. The General Dental Service in Scotland: an evaluation of findings reported by the Dundee Dental Health Services Research Unit. Community Dent Health 1985;2:225-36.
3. Elderton RJ, Davies JA. Restorative dental treatment in the General Dental Service in Scotland. Br Dent J 1984;157:196-200.
4. Elderton RJ, Eddie S. The changing pattern of treatment in the General Dental Service, 1965-1981. Part 2—restorative treatment and implications for the futures. Br Dent J 1983;144:421-3.
5. Elderton RJ, Nuttall NM. Variation among dentists in planning treatment. Br Dent J 1983;154:201-6.
6. Elderton RJ, Nuttall NM, Eddie S, Davies JA. Dental health services research in Scotland: a review of some 5-year results. Community Dent Oral Epidemiol 1985; 13:249-52.
7. Nuttall NM. The cost of General Dental Service treatment provided for dentate adults in Scotland. Br Dent J 1984;157: 160-4.
8. Davies JA. The relationship between change of dentist and treatment received in the General Dental Service in Scotland. Br Dent J 1984;157:235-9.
9. Bader, JD, Shugars DA. Variation in dentists' clinical decisions. J Public Health Dent 1995;55:181-8.
10. Nuttall NM, Pitts NB. Restorative treatment thresholds reported to be used by dentists in Scotland. Br Dent J 1990;169: 119-25.
11. El-Mowafy OM, Lewis DW. Restorative decision making by Ontario dentists. J Can Dent Assoc 1994;60:305-16.
12. Kay EJ, Nuttall NM. Relationship between dentists' treatment attitudes and restorative decisions made on the basis of simulated bitewing radiographs. Community Dent Oral Epidemiol 1994:22:71-4.
13. Nuttall MN, Davies JA. The capability of the 1983 children's dental health survey in Scotland to predict fillings and extractions subsequently undertaken. Community Dent Health 1988;5:355-62.
14. Pickles TH. The relationship of caries prevalence data and diagnosed treatment needs in a child population. Med Care 1970;8:463-73.
15. Long LM, Rozier RG, Bawden JW. Estimation of actual caries prevalence and treatment needs from field survey caries information on a child population in USA. Community Dent Oral Epidemiol 1979;7:322-9.
16. Bader JD, Shugars DA. Understanding dentists' restorative treatment decisions. J Public Health Dent 1992;52:102-10.
17. Bader JD, Shugars DA. Agreement among dentists' recommendations for restorative treatment. J Dent Res 1993;72:891-6.
18. Bader JD, Shugars DA, Rozier RG. Relationship between epidemiologic coronal caries assessments and practitioners' treatment recommendations in adults. Community Dent Oral Epidemiol 1993;21:96-101.
19. Stamm JW, Waller M, Lewis DW, Stoddart GL. Dental care programs in Canada. Historical development, current status and future directions. Ottawa, Canada: Canadian Government Publishing Centre, 1986:23-78, 116.
20. Ismail AI, Brodeur J-M, Gagnon P, et al. Prevalence of noncavitated and cavitated carious lesions in a random sample of 7–9-year-old schoolchildren in Montreal, Quebec. Community Dent Oral Epidemiol 1992;20:250-5.
21. MacInnis, WA, Ismail A, MacDonald R, Cunningham D. Clinical versus radiographic caries diagnosis in adults. J Dent Res 1992;71(Spec Iss):166.
22. de Vries HC, Ruiken HM, Konig KG, van't Hof MA. Radiographic versus clinical diagnosis of approximal carious lesions. Caries Res 1990;24:364-70.
23. Miller PA, Ismail AI, MacInnis WA. Restorative management of carious pits and fissures: a new approach. J Dent Res 1995; 74(Spec Iss):248.
24. Liang K-Y, Zeger SL. Longitudinal data analysis using generalized linear models. Biometrics 1986;42:13-22.
25. Zeger SL, Liang K-Y, Albert PS. Models for longitudinal data: a generalized estimating equation approach. Biometrics 1988;44:1049-60.
26. Ismail AI, Gagnon P. A longitudinal evaluation of fissure sealants applied in dental practices. J Dent Res 1995;74:1583-90.
27. Weerheijm KL, Gruythuysen RJM, van Amerongen WE. Prevalence of hidden caries. J Dent Child 1992;59:408-12.
28. Weerheijm KL, Groen HJ, Bast AJJ, Kieft JA, Eijkman MAJ, van Amerongen WE. Clinically undetected occlusal dentine caries: a radiographic comparison. Caries Res 1992;26:305-9.
29. Bader JD, Shugars DA. Variation, treatment outcomes, and practice guidelines in dental practice. J Dent Educ 1995;59: 61-95.
30. Hintze H, Wenzel A. Clinically undetected dental caries assessed by bitewing screening in children with little caries experience. Dentomaxillofac Radiol 1994;23:19-23.
31. Chan DCN. Current methods and criteria for caries diagnosis in North America. J Dent Educ 1993;57:422-7.
32. McKnight-Hanes C, Myers DR, Dushku JC. The influence of practice type, region, and age on treatment recommendations for primary teeth. Pediatr Dent 1992;14: 240-5.
33. Henke CJ, Epstein WV. Practice variation in rheumatologists' encounters with their patients who have rheumatoid arthritis. Med Care 1991;29:799-812.