Variation in the Use of Crowns and Their Alternatives

Daniel A. Shugars, D.D.S., Ph.D., M.P.H.; William J. Hayden, Jr., D.D.S., M.P.H.; James J. Crall, D.D.S., M.S., Sc.D.; Mark S. Scurria, D.D.S.

Dr. Shugars is Professor of Operative Dentistry, School of Dentistry and Sheps Center for Health Services Research, University of North Carolina at Chapel Hill. Dr. Hayden is President, Dental Delivery Consultants, Inc., Lee's Summit, MO. Dr. Crall is Professor of Pediatric Dentistry, School of Dental Medicine, University of Connecticut. Dr. Scurria is Assistant Professor of Prosthodontics, School of Dentistry, University of North Carolina at Chapel Hill. Direct correspondence to Dr. Shugars at the Department of Operative Dentistry, School of Dentistry, University of North Carolina, Chapel Hill, NC 27599-7450.
E-mail: dshugars.dentce@mhs.unc.edu

Abstract: The use of crowns and their alternatives for the restoration of compromised posterior teeth is of interest to educators, purchasers, and patients. Considerable curricular time is devoted to learning these techniques, substantial amounts of money are spent on these procedures, and differences in the outcomes of these treatments may have consequences for tooth survival. To begin to understand more about the actual use of these procedures, the provision rates of these services in a sample of U.S. dental practices were examined. This study reports on the extent to which utilization patterns and subsequent costs of crowns and their alternatives were associated with certain patient and practice characteristics. Insurance claims for dental services submitted by general dental practices through an electronic claims clearinghouse were used. Crown ratios (crowns/crowns plus alternatives) were calculated for dental practices to evaluate relationships with available explanatory variables. Findings indicated that older patients were significantly more likely to receive crowns than those in younger groups, resulting in as much as a 33 percent increase in the mean per tooth cost of treatment in the oldest group. Regional variation existed in the provision of crowns and resulted in up to a 31 percent difference in the mean per tooth treatment cost between regions. Crown ratios exhibited variation beyond that accounted for by patient and practice factors, thus raising questions about the consistency of treatment recommendations among dentists. These findings support the need to examine further the consistency of crown use among general dentists and to modify current approaches for teaching treatment planning in predoctoral restorative curricula.

Key words: variation, crowns, utilization, restorations, insurance claims

The recent Institute of Medicine (IOM) report recommends that the dental profession learn more about the outcomes of the treatments it provides.[1] The report also encourages dental educators to become engaged in both the expansion of this knowledge base and its incorporation into the dental curriculum. One area of dentistry in need of further study is the selection of the means of restoring posterior teeth with extensive caries, fractures, or large defective restorations. Knowledge of the service rates of crowns and their alternatives and the factors that influence their use has educational, policy, and quality of care implications.

Most schools teach that, for substantially compromised teeth, a crown is the preferred treatment when compared to the alternative, a direct amalgam or composite restoration.[2] However, the extent to which this teaching is reflected in practice is unknown. Thus, data characterizing actual service rates of crowns and crown alternatives would be useful to those responsible for teaching restorative dentistry to predoctoral students, which represents a large proportion of curriculum time.

Knowledge of the service rates of crowns and their alternatives and the factors that influence their use also has important policy implications. For ex-

ample, these services currently represent a sizable proportion of dental care expenditures in the United States.[3] Because crown prices are roughly six times greater than the price of the alternative treatment,[4] minor shifts in the patterns of uses of these services can substantially affect costs. Further, if the two approaches have different outcomes, then there are implications for the quality of care as well.

Thus the use of crowns and their alternatives is an important topic for educators, policy makers, and patients. This report describes a health services research project that addressed this topic by examining the extent to which certain patient and dental practice characteristics were associated with the provision of crowns rather than alternatives in posterior teeth, exploring the consistency of the provision of crowns among dental practices, and determining the cost implications of differences in the rates of provision of these restorations. The implications of the results for researchers, policy makers, and educators are then discussed.

Methods

Data. Data for this study were provided by an electronic insurance claims clearinghouse as a part of a larger study.[3] The parent database provided claims submitted by dental practices in forty-five states to more than thirty different carriers from June 1990 through May 1993. For this study we selected those general practices with claims for ten or more 3+ surface posterior restorations during the study period. Claims with invalid or missing patient or treatment variables (e.g., invalid patient year of birth or duplicate claims for the same tooth/patient/procedure) were excluded from the sample. The final sample represented 58,165 restorations for 39,697 patients from 728 general dental practices. Many of the practices that were excluded began using the clearinghouse at the end of the study period and thus had insufficient numbers of claims. The distribution of patient characteristics (age, gender), restoration types (crowns, alternatives), and practice locations of the study sample are shown in Table 1.

Analysis. To examine the relative use of crowns, we developed a measure we termed the "crown ratio" (CR). The CR was defined as the number of crowns (and onlays) claimed divided by the total number of claims for crowns plus crown alternatives. Crown alternatives were defined as amalgam or composite restorations with three or more surfaces. Thus, a CR of 0.2 means that the practice submitted a claim for one crown for every four alternatives claimed.

Survey Data Analysis (SUDAAN) computer software[5] was used to estimate crown ratios and their standard errors across cross-classifications of four geographic regions, three age groups, dental arch, posterior tooth type, and gender. This software was developed for use in complex survey sample designs where multi-stage sampling is applied in various strata. Thus, this analytic approach provides population estimates that account for possibly unequal probabilities of selection and the clustering within what is

Table 1. Characteristics of the sample

	Patients					Restorations		Practices
	Age Cohorts			Gender				
Region*	18-34	35-50	51-99	M	F	Crowns	3+Surface Amalgam/ Composites	
NE	2,581	3,623	1,473	4,164	3,513	3,268	7,975	151
S	5,825	8,494	3,506	9,867	7,958	12,679	13,173	378
MW	3,203	5,008	2,150	5,813	4,548	6,883	8,602	128
W	1,246	1,755	833	2,142	1,692	2,878	2,707	71
Totals	12,855	18,880	7,962	21,986	17,711	25,708	32,457	728

* NE = ME, VT, CT, NH, RI, MA, NJ, NY, PA
S = NC, SC, VA, WV, DE, MD, DC, FL, GA, AL, KY, MS, TN, AR, LA, OK, TX
MW = MO, IA, KS, MN, ND, SD, NE, IL, IN, MI, OH, WI
W = CA, AK, HI, WA, OR, AZ, CO, ID, MT, NV, NM, UT, WY

termed the primary sampling unit (PSU). In this study, the practice is the PSU with dentists, patients, and teeth clustered within a practice. Logistic regression was used to compute odds ratios and their confidence intervals through models for the association of CR with each explanatory factor separately and for models that adjusted for all explanatory factors simultaneously. The explanatory factors available in the data set were region, age group, gender, posterior tooth type, and tooth arch. Region was included to examine geographic variation in practice patterns. Patient characteristics were included as possible factors that could be associated with provision rates.

To explore the consistency of crown provision, two variables were calculated for each practice. The first was the observed or actual ratio of crowns/(crowns + alternatives). The second was the predicted crown ratio for each practice adjusted for region, age group, gender, dental tooth arch, and tooth type. A ratio of the observed and predicted CRs was calculated to determine the extent to which the observed utilization rates varied from the predicted, and served as an estimate of the effect the practice had on crown utilization.

Finally, to determine the effect of variation in CRs on treatment costs, the average cost of restoring a tooth requiring a crown or its alternative was calculated for each level of the explanatory variables. The mean national fees reported by the American Dental Association for these services were used in these calculations.[4]

Results

The adjusted crown ratios for region, age group, gender, tooth type, and dental arch are shown in Table 2. The overall ratio was 0.44. Ratios ranged from lows of 0.29 in the Northeast region and 0.32 in the eighteen to thirty-four year old age group to a high of 0.56 in the over fifty age group. Model-predicted unadjusted odds ratios calculated for each of these variables are shown in the first column of Table 3. The odds of receiving a crown, defined as CR/(1-CR), versus its alternative were higher in all regions compared to the northeast. Each succeeding age group displayed significantly greater odds of receiving crowns compared to younger groups. Females and mandibular teeth had slightly higher relative odds for crowns compared to their respective counterparts. In the adjusted main effects model, all trends persisted.

Table 2. Adjusted crown ratios,* grouped by selected variables and for practices overall

Variable	Crown Ratio	95% CI
Region		
NE	.29	(.25, .33)
S	.49	(.45, .53)
MW	.44	(.40, .48)
W	.52	(.41, .65)
Age		
18-34	.32	(.30, .34)
35-50	.47	(.45, .49)
51 +	.56	(.54, .58)
Gender		
M	.43	(.41, .45)
F	.46	(.44, .48)
Tooth Type		
2nd Molar	.45	(.43, .47)
1st Molar	.46	(.44, .48)
2nd Premolar	.39	(.37, .41)
1st Premolar	.44	(.40, .48)
Arch		
Maxillary	.40	(.38, .42)
Mandibular	.49	(.47, .51)
Overall	.44	(.42, .46)

*Crown Ratio = # crowns / # crowns + # alternatives (3+ surface amalgam/composites)

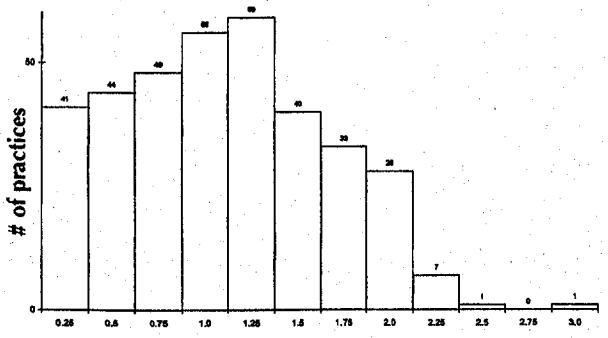
Figure 1 presents the distribution of the ratio of observed and predicted CRs for all practices, with the predicted CR adjusted for all patient and tooth level characteristics. This descriptive approach was chosen because statistical tests of the significance of the variation in these ratios would be inappropriate due to the relatively small sample sizes for each practice. A value of .5 for the ratio of observed/predicted CRs means that only one-half of the predicted number of crowns were actually provided by a practice. In contrast, a value of 1.5 means that a practice provided crowns at 150 percent of the predicted rate. For the purpose of this study, the 43 percent (n=155) of the practices that provided crowns at either 50 percent less or 150 percent more than expected were categorized as outliers. Furthermore, when observed/predicted CRs were categorized into one of three groups (ratio < 0.5, 0.5 to 1.5, > 1.5) within each region, the Midwest region displayed proportionately fewer out-

Table 3. Unadjusted and adjusted odds ratios for comparisons of crown ratios among categories of a variable

Comparison	Unadjusted Odds Ratio	Unadjusted 95% CI	Adjusted* Odds Ratio	Adjusted* 95% CI
Region				
W vs NE	2.56	(2.44, 2.78)	2.63	(2.50, 2.86)
MW vs NE	1.96	(1.85, 2.04)	1.92	(1.85, 2.04)
S vs NE	2.33	(2.22, 2.44)	2.38	(2.27, 2.50)
W vs MW	1.32	(1.25, 1.41)	1.37	(1.30, 1.47)
W vs S	1.11	(1.04, 1.18)	1.11	(1.05, 1.19)
S vs MW	1.2	(1.15, 1.25)	1.23	(1.18, 1.29)
Age				
51+ vs 18-34	2.70	(2.56, 2.86)	3.03	(2.94, 3.23)
51+ vs 35-50	1.43	(1.37, 1.49)	1.52	(1.45, 1.59)
35-50 vs 18-34	1.89	(1.82, 1.96)	2.04	(1.96, 2.13)
Gender				
Female vs Male	1.13	(1.09, 1.17)	1.21	(1.17, 1.25)
Dental Arch				
Mand vs Max	1.48	(1.43, 1.53)	1.46	(1.41, 1.51)
Tooth Type				
1st Pre vs 2nd Molar	1.05	(0.99, 1.11)	1.09	(1.03, 1.16)
1st Pre vs 1st Molar	1.08	(1.03, 1.14)	1.23	(1.16, 1.31)
1st Pre vs 2nd Pre	1.22	(1.15, 1.30)	1.19	(1.11, 1.27)

* Each odds ratio is adjusted for all of the other variables in this table (e.g., each region comparison is adjusted for age, gender, dental arch, and tooth type).

Figure 1. Distribution of practices by observed/ predicted crown ratios



lier practices, those with observed ratios 50 percent above or below the predicted (Figure 2). In contrast, the Northeast and West regions had substantially more outliers, practices with ratios less than 0.5 or greater than 1.5.

Across the entire sample, the average cost of restoring a tooth requiring either a crown or its alternative was $225 (Table 4). The most notable differences in the average cost per tooth were seen when comparing the eighteen to thirty-four age group ($181) with the fifty and over group ($269) and when comparing the Northeast ($173) and the West ($251). Moreover, the size of the confidence interval for the West ($80) signals substantial variation within that region.

Discussion

Methodological considerations. The posterior crown ratio, which relies on the assumption that the decision to treat a tooth has been made, appears to be a useful measure of the relative use of high and low cost treatment alternatives in situations where extensive restoration of a tooth is deemed necessary. This ratio permits analysis of rates of use of treatment alternatives and appears to be sensitive to factors (e.g., patient age and tooth location) thought to affect crown utilization. The CR is helpful in highlighting differences in provision of these services, and it may also be helpful in planning costs of care for insured populations.

Assessment of provision of treatment across den-

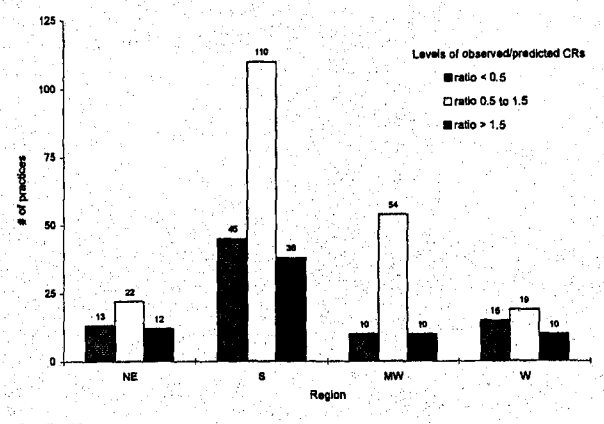
Table 4. Mean cost of restoring a posterior tooth requiring a crown or large restoration*

Variable	Mean Cost ($)	95% CI
Overall	**225**	**(216, 234)**
Region		
NE	173	(157, 188)
S	242	(229, 254)
MW	225	(209, 241)
W	251	(211, 291)
Age		
18-34	181	(171, 190)
35-50	236	(227, 246)
51 +	269	(259, 279)
Gender		
M	229	(220, 239)
F	219	(210, 228)
Tooth Type		
2nd Molar	229	(197, 216)
1st Molar	232	(214, 236)
2nd Premolar	207	(234, 253)
1st Premolar	225	(200, 218)
Arch		
Maxillary	208	(222, 241)
Mandibular	243	(219, 240)

* Mean cost for each group was calculated using standard, nationally reported mean fees for the respective restorations,[4] and adjusted for all variables and clustering within practices.

Figure 2. Regional distribution of practices by observed/predicted CRs*

***adjusted for other main effects**



tal practices has been restricted by data limitations. Previously, data were available only from practices in a single state/region and/or claims submitted to a single carrier.[6,7,8] A single carrier data source could be termed "patient-based" as it contains all claims for individual patients across one or more providers. Clearly, the "patient-based" data sources have the advantage of being able to examine what happens to a patient. In contrast, this clearinghouse database is "provider-based" as it collects a substantial proportion of claims from individual practices that are submitted to multiple carriers. Compared to a single carrier data source, this database provides a greater number of observations per practice albeit for fewer practices. Thus this database can allow a more accurate depiction of individual practices, and it permits the examination of treatment provision at the level of a dental practice. Although the practice-based approach does limit the actual number of practices that can be observed, this database does provide a unique opportunity to examine patterns of service provision across the dental marketplace.

It is important to recognize that because of the characteristics of the database used in this study, broad generalization is not appropriate. For instance, practices in this data set have self-selected to submit claims through one of the new clearinghouses; they could be categorized as "early adopters" of a relatively new technology in dentistry. Accordingly, they may demonstrate practice characteristics different from the rest of the population. Thus, this sample cannot be assumed to be representative of the general patient population or of all dentists' treatment behaviors. However, because all patients whose treatment is captured in this database by definition possess dental insurance, these findings may approximate the utilization characteristics of the insured population. More definitive conclusions should be delayed until data from a broader spectrum of practices and additional practice characteristics are available for analysis. As is occurring in other health care sectors, the next step is to examine utilization behaviors across a larger number of practices to replicate these findings.

Policy issues. Even with the limitations in generalizability, these findings raise questions about the cost and appropriateness, and hold implications for the profession's knowledge of the relative effectiveness of crowns and their alternatives. Selected patient characteristics were found to be associated

with differences in the provision of these restorative services. Overall, posterior teeth that were restored in this sample were slightly less likely to receive a crown compared to the alternative of an amalgam or a composite. However, compared to those under age thirty-five, those patients over age fifty in our sample had nearly three times higher odds of receiving a crown than a 3+ surface amalgam/composite. The higher crown ratios in the older groups are not surprising and are likely an indirect reflection of the decreasing prevalence of complete edentulism that results in a larger proportion of previously restored teeth at risk for restoration replacement.[9] Presumably, the high proportion of previously restored teeth among these older individuals is related in part to this cohort's disease and restoration experience. In contrast, those currently in the under thirty-five age group are likely to have fewer caries, and fewer restorations, than that experienced twenty years ago by the current over fifty group. Thus, it remains to be seen if the higher crown ratios seen in the fifty-plus group will occur in current younger cohorts as they age.

In addition to patient characteristics, geographic location of practices was also associated with variations in crown provision. At the regional level, the adjusted odds ratios demonstrated that regional variation did exist, albeit due primarily to lower CR in the Northeast. When provision rates at the practice level, adjusted for patient factors, were analyzed, the observed rate of many practices varied considerably from the predicted rate. A brief explanation of the variation in the ratio of observed and predicted CRs provides an illustration of the practical implications of this ratio of CRs. Assume that a practice submitted claims for eighteen restorations, six crowns, and twelve alternatives. The observed CR would be 0.33 (six crowns/eighteen total). Say, for example, the predicted CR, which adjusts for patient and tooth factors, was 0.67 (twelve crowns/eighteen total). Then the ratio of observed and predicted CRs would be about 0.5 (0.33/0.67). Thus this ratio of observed and predicted CRs indicates that this practice was providing crowns at about one-half the expected rate. Plausible explanations of the variation found in this analysis are that it results from differences in disease rates, differences in dentists' practice styles, or other unmeasured characteristics. In the absence of data to suggest dramatic differences in disease rates, however, much of this variation is most likely attributable to idiosyncrasies of providers, which is consistent with previous observations.[10] In some ways, the variability among practices with respect to crown utilization could reflect the profession's general lack of knowledge of treatment effectiveness and the consequent unavailability of practice guidelines.[11] This situation could lead to provider uncertainty, overconfidence, or particular enthusiasm[12] regarding the use of these services.

From a population perspective, differences in crown ratios can have substantial cost implications. Since crowns can cost up to six times that of the alternative, seemingly small differences in crown utilization can have profound effects on overall costs. For example, the average cost of restoring a tooth needing extensive restoration was nearly 33 percent higher in the group of fifty-one plus year olds compared to those under thirty-five. Also the average cost of restoring a tooth in the Northeast region was substantially lower than the national average. Thus, those planning to finance dental services delivered in the private sector could expect to find these trends in cost differences when financing care for groups with these characteristics.

The variation found in the provision of crowns at the practice level also raises concerns about the appropriateness of care. Those practices at the tails of the distribution of observed/predicted crown ratio could represent either under- or overutilization of crowns, neither of which is desirable. However, a determination of appropriateness depends upon comparison with a known standard of treatment effectiveness, which is currently unavailable.[13] Thus, these findings further highlight the need to expand the scientific base of clinical dentistry. If the inconsistency found in this sample of practices persists when other samples are studied, then the importance of knowing the relative effectiveness of these treatments becomes critical as we attempt to control costs and assure appropriateness.

Educational implications. If a substantial portion of the variation noted in this study is indeed due to dentists' idiosyncratic use of crowns, the profession has a clear indication of the need for improvements in dental education. At the dental student level, we must strive to include a complete discussion of risks and benefits of alternate therapies in treatment planning decisions. In continuing education we must challenge practitioners to analyze their own treatment planning processes for evidence of a realistic assessment of the cost and consequences of treatment alternatives.

At the treatment planning stage of care, mere

pattern recognition followed by an automatic prescription of therapy is often the norm.[14] Without an explicit diagnosis and assessment of risk, the prescription of a crown for every situation in which considerable tooth structure is missing is questionable. For example when dentists were asked their reasons for crown placement, one study indicated that 44 percent of crown recommendations were based on the perceived need to prevent tooth or cuspal fracture.[15] Yet even with this "diagnosis" of risk of fracture, little is actually understood about which individual teeth are at highest risk of fracture.[16] Researchers must identify better indicators of cuspal fracture for individual teeth.

As noted earlier, the recent Institute of Medicine (IOM) report charged dental educators to "incorporate in all educational activities a focus on outcomes and an emphasis on the relevance of scientific knowledge and thinking to clinical choices."[1] However, our knowledge of outcomes in this area is lacking. For example, substantial disagreement exists about what are reasonable life expectancies for these various restorations.[17] Further, our understanding of the physiological and psychological impacts of restorative treatment suffers the same lack of sound information. Data from the recently reported NHANES III study indicates that up to 31.5 percent of patients have defective intracoronal restorations and up to 6.7 percent have defective crown or bridge retainers.[9] Given disagreement over restorative life expectancies and solid data to suggest a high rate of failure regardless of restoration type, projecting the lifetime cost of care for a single tooth may be nearly impossible. Yet lifetime cost of care may be a more important outcome measure than initial placement cost to patients and payers alike.

Clearly the profession has much to learn about even such long-practiced treatments as direct restorations and crowns. With a rapidly expanding array of treatment options, outcomes research must include not only the newest forms of treatment but also conventionally accepted treatments.[18] Much of the IOM report calls for a broadening of this scientific base. Researchers and clinicians must work together to identify those measures most critical to providing appropriate care and to develop data collection schemes most likely to document those outcomes efficiently and accurately. As these data are collected and analyzed, current treatment planning education must include the best information to teach students and practitioners to think critically, diagnose accurately, assess risk, and prescribe appropriate treatment.

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