Scientific Article

Analysis of the Demographic Characteristics of Pediatric Dental Practice Sites

Eric S. Solomon, DDS, MA[A]

Abstract: ***Purpose:*** *The purposes of this study were to: (1) investigate the demographic characteristics of pediatric dental practice sites in the United States; and (2) develop a model that identifies practice site characteristics commonly associated with pediatric dental practices.* ***Methods:*** *Demographic data and pediatric dental practices were organized by zip codes and analyzed using discriminant analysis. The demographic characteristics associated with zip codes that contained a pediatric dental practice were determined.* ***Results:*** *The resulting model correctly classified 92% of the 30,134 zip code areas, based upon the presence or absence of a pediatric dental practice. The variables most closely associated with a zip code containing a pediatric dental practice included: (1) number of dental practices (general practice); (2) percent of the adult population with a college degree; and (3) population size.* ***Conclusions:*** *Demographic characteristics are predictive of sites with or without a pediatric dental practice. Zip codes with large, urban populations that have positive socioeconomic characteristics, such as high income and education levels, are the most likely to have a pediatric dental practice. There are a significant number of zip codes in the United States (1,712) that have the demographic characteristics associated with a pediatric dental practice site but do not have a pediatric dentist in them. (Pediatr Dent 2007;29:214-9)*

KEYWORDS: PRACTICE SITE LOCATION, DEMOGRAPHIC CHARACTERISTICS, PEDIATRIC DENTAL PRACTICES

Manpower data indicate that dentistry is entering a period of unprecedented change. Dentist-to-population ratios are decreasing and will probably continue to decrease for at least the next decade.[1] The demand for dental services, however, is at an all time high based on the number and percent of the population that visit the dentist on a regular basis.[2] In terms of supply, the number of active private practicing pediatric dentists has increased by 48% between 1987 and 2002.[3] As the number of pediatric dentists entering practice increases, they are able to meet the need for pediatric dental services in an increasing number of locations. Therefore it is critically important that all pediatric dental graduates make a sound practice location decision so that they have the opportunity to employ their valuable skills in an area where their services are sought after.

There are few studies that directly address the problems associated with site selection of a dental practice.[4] Students graduating from dental school in the 1970s have been characterized as "irrational" regarding their practice location decision.[5] Prior to the 1980s, most dentists selected a location because they grew up in a community or completed their dental training there.[6] During the 1980s, graduates were starting to consider the dentist-to-population ratios, but again they were still using subjective criteria rather than objective analysis.[7] Most of the literature during this period was focused on a checklist[8] or "exhortatory" categories.[9] The large number of variables involved in making this complex decision has led to the use of a process termed "suboptimization" (ie, utilization of the best data available).[10] It was becoming evident that it was imperative to find quantifiable tools to aid dentists in the location selection process. To this end, the literature of the 1990s began to utilize increasingly more sophisticated statistical models to identify the importance of the variables affecting practice location.[11-13]

The selection of a practice location site can be the single most important business decision a pediatric dentist can make. The key to making a good practice location decision is the identification of an area of need. This involves finding a site where the population values pediatric dental care and has the wherewithal to secure it. Secondarily, but no less important, is the assessment of the number of practicing pediatric dentists already established in the area of interest.

The purpose of this paper was to attempt to further an understanding of the practice site location decision by identifying and quantifying the location characteristics that are most closely associated with existing pediatric dental practice sites. As a group, practicing pediatric dentists generally

[A]*Dr. Solomon is Executive Director, Institutional Research, The Texas A&M Health Science Center, College Station, Tex, and is professor, Public Health Sciences, Baylor College of Dentistry, Dallas, Texas.*
Correspond with Dr. Solomon at esolomon@bcd.tamhsc.edu

achieve financial success. This would not be true if most pediatric dentists had made poor practice location decisions. Therefore, the authors have inferred that most pediatric dentists have chosen locations that have favorable characteristics. The basic premise of this research is that potential areas for new locations can be found using information about the characteristics of existing practice locations.

Methods

To conduct the investigation of the practice location characteristics of pediatric dentists, relevant data needed to be secured and an appropriate statistical technique had to be chosen for analysis. Data on practicing pediatric dentists and demographic characteristics of their practice location sites were assembled, and discriminant analysis was selected as a statistical technique capable of distinguishing between the location characteristics of sites with a pediatric dentist vs sites that do not have a pediatric dentist.

Data on practicing dentists in the United States were obtained from American Medical Information, Inc. (AMI) a division of infoUSA (Omaha, NE). These data also included the specialty status of the dentists. This data source is highly reflective of the practicing dental community, since these data are based upon yellow page and business white page listings of dentists. The accuracy of these data is vigorously maintained. These data are updated once a month for additions, changes, and deletions. In addition, these data are run through the National Change of Address database for mailing address accuracy and the records are verified by phone once or twice a year. The data in this study were current as of December 2005 and included all dental practices in the United States. The data set does not differentiate between primary and satellite practice sites—thus, all practice sites are treated equally. Consequently, the analysis is based upon pediatric dental practices, not pediatric dentists.

Zip codes were used as the unit of analysis for this project because practice locations can be determined using addresses and because census data are available for zip codes. Demographic data were assembled for all geographic zip codes in the United States (zip codes that represent post office boxes were not included). Data for analysis represented the following areas: (1) income; (2) demographics; (3) educational background; (4) housing characteristics; (5) characteristics of the employed population; (6) urbanization (urban vs rural areas) and (7) the number of general dental practices. Unless noted, all data items are estimated for 2005.

Discriminant analysis is a statistical technique that builds a predictive model of group membership based on the characteristics of each case. It is valuable in determining which variables are most useful for discriminating among groups. The presence or absence of a pediatric dental practice in a zip code provided the basis for classifying group membership in the discriminant model. Therefore, there were 2 groups of zip code areas created—those with a pediatric dental practice and those without one. Discriminant analysis requires that: (1) all predictor variables have a normal distribution; and (2) they all should have a similar covariance matrix. Accordingly, the variable set was screened, and the population variable was found to be highly skewed. The population data were converted to a more normally distributed variable by taking their square root and using that in the analysis.

Variables describing the characteristics of the zip code areas were entered into the model in a stepwise fashion, based upon their ability to predict group membership. Each potential predictor variable was entered into the model based upon the computation of an F statistic. The F statistic measures the change in the Wilks' Lambda statistic when the variable is added to the equation. The Wilks' Lambda indicates the degree of separation between the means (centroids) of the 2 groups. Therefore, as statistically significant variables are added to the equation, the Wilks' Lambda statistic decreases and the model is better able to predict group membership. Because of the large number of cases, only variables with a statistically significant F statistic ($P \leq .001$) were entered into the equation. The stability of the model was validated by running the model on various samples of the entire population and by performing a cross validation procedure.

Results

Of the 153,503 dentists in this study, 4,420 were identified as pediatric dentists. Data from the American Dental Association (ADA)[14] indicate that there were 156,921 active private practitioners in 2002—a number reasonably comparable to the 153,503 private practitioners in this study. The number of pediatric dentists in this study roughly corresponds to the 4,035 practicing pediatric dentists reported by the ADA in 2002. Of the total number of dentists in this study, 14,321 (9%) had practices that were located at more than one site. Consequently, there are a total of 171,385 dental practices in the database—of which 5,252 were identified as pediatric dental practices. There were 695 pediatric dentists (16%) who had multiple practices—for an average of 2.13 each.

A total of 30,134 zip code areas were analyzed using discriminant analysis. Two groups were identified:

a. 2,697 zip code areas containing a pediatric dental practice; and

b. 27,437 zip code areas without a pediatric dental practice.

The model classified these zip code areas into one of these 2 groups based upon the characteristics of the areas. Six variables were entered into the equation. The Wilks' Lambda statistic for the resulting model was 0.576, indicating that the model was able to explain almost half of the total variance,

and the F-statistic was significant for each variable entered into the equation ($P<.001$). The group centroids were -0.269 for the zip code group without a pediatric dental practice and 2.737 for the zip code group with a pediatric dental practice.

The following variables were entered into the model sequentially:

1. no. of general dental practices;
2. percent of population with a college degree;
3. total population;
4. percent of population over 64 years old;
5. percent of population between the ages of 18 to 40; and
6. percent of population under 18.

The sequence indicated which variables were best able to discriminate between zip codes with and without a pediatric dental practice. The unstandardized discriminant function coefficients showed the relationship of the variables to the model:

1. no. of general dental practices (0.14362803);
2. percent of population with a college degree (1.36335407);
3. population (0.00000563);
4. percent of population over 64 (-0.99120218);
5. percent of population between 18 to 40 (-0.89537494);
6. percent of population under 18 (.82380430); and
7. constant (-0.70638763).

Most of the coefficients were positive, indicating a positive relationship to areas with a pediatric dental practice. Two of the variables, however, had a negative value (percent of the population older than 64 and percent of the population between the ages of 18 and 40). Consequently, zip codes with high values for these variables were more likely to not have a pediatric dental practice.

When the model's unstandardized discriminant function coefficients were applied to the values of the variables in that area, the model produced a discriminant score for each zip code. These discriminant scores were used to predict group membership. As the group centroids indicate, lower values of discriminant scores were associated with areas that do not have a pediatric dental practice while higher values were associated with zip codes that did have a pediatric dental practice. Accordingly, zip codes with a discriminant score above 1.233 were predicted to be in the pediatric dental practice group. When compared to the actual presence or absence of a pediatric dental practice, the discriminant scores correctly classified 92% of all zip code areas into their respective groups. Within each group, 94% of the zip code areas without a pediatric dental practice and 76% of the zip code areas with a pediatric dental practice were correctly classified (Table 1).

A cross validation procedure was run to diminish any possible bias in the estimation of the coefficients. The cross validation produced a nearly identical classification (Table 2). In order to determine the model's stability:

1. a random sample equivalent to 20% of all the zip codes (6,072) was drawn; and a
2. discriminant function analysis was conducted on this subset of the data.

The resulting model had 6 variables—all of which were included in the model using the entire data set. The classification results were also similar, with 92% of all zip codes correctly classified (93% of zip codes without a pediatric dental practice and 76% of zip codes with a pediatric dental practice).

The model was successful in classifying zip codes that did or did not have a pediatric dental practice. Almost half (46%) of the zip codes that had a pediatric dental practice, however, had more than one pediatric dental practice in

Table 1. CLASSIFICATION RESULTS OF DISCRIMINANT ANALYSIS COMPARING THE ACTUAL LOCATION OF PEDIATRIC PRACTICES TO THE MODEL'S PREDICTION OF PEDIATRIC PRACTICE LOCATIONS

		Predicted Group Membership		Total
		NO Pediatric Dental Practice	Pediatric Dental Practice	
COUNT	Zip codes without a pediatric dental practice	25,725	1,712	**27,437**
	Zip codes with a pediatric dental practice	656	2,041	**2,697**
%	Zip codes without a pediatric dental practice	94	6	**100**
	Zip codes with a pediatric dental practice	24	76	**100**

the zip code. The authors wanted to investigate whether the model was capable of discerning zip codes with multiple pediatric dental practice sites vs zip codes with a single pediatric dental practice. Once again, the authors utilized the model's discriminant scores for this analysis. They divided zip codes into 3 categories: (1) zip codes without a pediatric dental practice; (2) zip codes with a single pediatric dental practice; and (3) zip codes with more than one pediatric dental practice. The discriminant scores were used as the dependent variable in a 1-way analysis of variance (ANOVA) with a multiple range test. The 1-way ANOVA showed whether the 3 groups are significantly different statistically based upon the values of the discriminant scores. The multiple range test indicated whether the 3 groups of zip codes were homogeneous or statistically different. The ANOVA results were statistically significant ($P<.001$). This indicated that the 3 groups of zip codes were significantly different based upon their discriminant scores. A multiple range test was conducted and showed that each group of zip codes was statistically significantly different ($P<.01$). In addition, the pairwise differences between the 3 different group types were all statistically significantly different ($P<.001$). The zip codes with multiple pediatric dental practices had the highest average discriminant score followed by the zip codes with a single pediatric dental practice. The lowest average discriminant score was for the zip codes with no pediatric dental practice.

Discussion

The literature addressing the demographic characteristics of dental practice sites has used methods of evaluation that were appropriate to the times, but these studies fail to meet modern day standards.[6-10] As statistical modeling techniques have become more sophisticated, the variables affecting practice location sites can now be identified with a high level of confidence.[11-13] With this in mind, discriminant analysis was employed in this study to answer 2 questions:

1. Do zip code areas with a pediatric dental practice have different location characteristics than areas that do not have a pediatric dental practice?
2. What location characteristics are most important in discriminating between these 2 areas?

The results of the discriminant analysis suggest that there are significant differences in the location characteristics of zip codes that do or do not contain a pediatric dental practice. The model was able to explain almost half of the total statistical variance and correctly classify over 92% of all the zip codes.

Six variables were entered into the discriminant analysis model in a stepwise fashion with the variables having the highest statistical significance entering the equation earliest. Statistically, the number of general dentists in the zip code had the greatest explanatory power and was, therefore, entered into the equation initially. From a conceptual standpoint, it is realistic that this variable would have the highest level of statistical significance. Much of the practice of pediatric dentistry is built upon a referral network. The general dentist provides the backbone of this network, so it is reasonable to surmise that proximity to potential referral sources would be an extremely important practice location feature. The second variable in the equation is the percent of the adult population who had completed a college degree. Here we observed the positive impact of educational achievement in determining the practice location characteristics of pediatric dentists. Not surprising is the relevance of the third variable entered into the equation—population size. Without a sufficient population base, a pediatric dental practice could not succeed.

Table 2. CROSS-VALIDATED CLASSIFICATION RESULTS OF DISCRIMINANT ANALYSIS COMPARING THE ACTUAL LOCATION OF PEDIATRIC PRACTICES TO THE MODEL'S PREDICTION OF PEDIATRIC PRACTICE LOCATIONS

		Predicted Group Membership		Total
		No Pediatric Dental Practice	Pediatric Dental Practice	
COUNT	Zip codes without a pediatric dental practice	25,725	1,712	**27,437**
	Zip codes with a pediatric dental practice	658	2,039	**2,697**
%	Zip codes without a pediatric dental practice	94	6	**100**
	Zip codes with a pediatric dental practice	24	76	**100**

The next 3 variables entered into the equation are related to population demographics. The percentages of the population that were over 64 years old and 18 to 40 years old had a negative relationship to the model. Therefore, areas with a high percentage of older people and a high percentage of young adults were not likely to have a pediatric dental practice. The percentage of the population under 18 was the last variable in the equation. Its positive coefficient shows that areas where families have a large number of children (a high percentage of their population who are less than 18 years old) are likely to have a pediatric dental practice. It is certainly reasonable to assume that areas with a high concentration of children and adolescents would be a logical place to locate a pediatric dental practice.

The model's ability to identify zip codes with multiple practices was an extremely important validation of the modeling process. Since almost half of all zip codes with a pediatric dental practice had more than one practice, it was important to be able to determine whether the model was capable of recognizing this group. The discriminant scores used in this analysis are the statistical representation of each zip code based upon the model's coefficients and the variables' values for the zip code. The analysis of this classification scheme demonstrated that zips codes with multiple pediatric dental practices had significantly higher discriminant scores. This means that the variables predicting the presence of a pediatric dental practice in an area can also be used to predict multiple practices. In other words, the more general dentists in an area, the more highly educated the population. Also, the larger the population, the more likely it will be to find multiple pediatric dental practices.

The unstandardized discriminant function coefficients can be used to evaluate a zip code as a potential practice site. One can produce a discriminant score for the zip code by multiplying the coefficients by the actual data for that zip code. As the model results indicate, the higher the score, the more likely that zip code has the characteristics associated with most pediatric dental practice locations. The group centroid for the pediatric dental practice group was 2.737; therefore, any score in that range would indicate a zip code that had the characteristics typically associated with a pediatric dental practice.

It is appropriate to evaluate the success of this modeling effort from both conceptual as well as practical grounds. The conceptual framework is based upon the validity of using the sites of existing pediatric dental practices to determine relevant practice location characteristics. Therefore, the model will be most successful at predicting the site characteristics of a "typical" pediatric dental practice site. As one might expect, the "typical" site is a zip code with a large, urban population that has positive socioeconomic characteristics, such as high income and education levels. Since these are the practice site characteristics that have commonly been associated with pediatric dental practices, the modeling effort is satisfying from a conceptual standpoint.

There are, however, potential drawbacks to analyzing pediatric dental practices rather than pediatric dentists. Twenty-nine percent of the pediatric dentists in this data set had more than one practice site, so at least 29% of the practices do not have a full-time pediatric dentist. Therefore, a tacit assumption of this model is that the demographic characteristics that represent a pediatric dentist's primary practice site are the same as those characteristics that are representative of a satellite practice site. Analyzing pediatric dental practices may still be the preferred approach. This is because the effort required in gathering detailed data on each pediatric dentist's time commitment at every practice site might not result in a significantly better model.

Another possible limitation of this model is that it only considers the demographic characteristics of an area in relationship to the practice location decision. There are also personal factors that can influence the practice location decision. Some of these personal factors might include:

1. proximity to family;
2. a spouse's career;
3. a return to one's home town;
4. access to recreational and cultural activities; and
5. something as practical as the availability of an "ideal" practice for sale.

Further research is indicated to gain insight into the relationship between the demographic vs the personal factors in the practice location decision process.

The classification procedure's results show that not all pediatric dentists are located in "typical" practice sites. In fact, there were 656 zip codes with a pediatric dental practice that did not adhere to the model (24% of all pediatric practice sites). There can be several explanations for this occurrence. A practice location decision based solely upon personal criteria, as discussed above, could be one explanation. Another possibility is linked to the age of the practice. Demographic characteristics of an area can change through time. The characteristics of a practice site at its inception can change as the area ages. An area that was favorable at its inception might not be so 30 years later. Further study of this phenomenon might improve the model's predictability.

The widespread demand for pediatric dental services suggests that practice location sites other than those identified as "typical" in this paper may still be viable practice sites. The results of this research, however, also suggest that additional consideration is advised when contemplating an "atypical" practice location site. The zip codes classified as having the characteristics of a "typical" pediatric dental

practice generally had multiple practices in them. Of these "typical" areas that had a pediatric dental practice, over half (52%) had multiple pediatric dental practices. Conversely, zip codes with a pediatric dental practice not classified as "typical" usually had a single pediatric dental practice (72%). These data tend to corroborate the viability of practice sites with the characteristics identified in the model.

Analysis of the data revealed 1,712 zip codes that had the site location characteristics of a "typical" pediatric dental practice site, but no pediatric dental practice. Consequently, there appear to be viable sites available for pediatric dentists who want to practice in a "typical" practice site. For those who want to locate in areas with site characteristics associated with current pediatric dental practices, the authors have simplified their investigation by identifying the variables most closely associated with existing practices. These data can be utilized more effectively when entered into a geographic information system (GIS). The mapping capability of the GIS provides the pediatric dentist the ability to visualize the spatial relationships between prospective practice locations. As such, this technology can help simplify what are currently often complex practice location decisions. In addition, these data can be used to provide valuable information for both demographic and manpower planning by the specialty.

Conclusions

Based upon this study's results, the following conclusions can be drawn:

1. Demographic characteristics are predictive of sites with or without a pediatric dental practice. The model developed for this paper was able to correctly classify 92% of all US zip codes as to whether they did or did not contain a pediatric dental practice.
2. Zip codes with large, urban populations that have positive socioeconomic characteristics, such as high income and education levels, are the most likely to have a pediatric dental practice. The higher these values are, the more likely the area will have multiple pediatric dental practices.
3. There are a significant number of zip codes in the United States (1,712) that have the demographic characteristics that are "typical" of sites with a pediatric dental practice but do not have a pediatric dental practice in them.

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