Practice Characteristics Associated with Patient-Specific Receipt of Dental Diagnostic Radiographs

Gregg H. Gilbert, Richard A. Weems, Mark S. Litaker, and Brent J. Shelton

Objective. To quantify the role of practice characteristics in patient-specific receipt of dental diagnostic radiographic services.

Data Source/Study Setting. Florida Dental Care Study (FDCS).

Study Design. The FDCS was a 48-month prospective observational cohort study of community-dwelling adults. Participants' dentists were asked to complete a questionnaire about their practice characteristics.

Data Collection/Extraction Methods. In-person interviews and clinical examinations were conducted at baseline, 24, and 48 months, with 6-monthly telephone interviews in between. A single multivariate (four radiographic service outcomes) multivariable (multiple explanatory covariates) logistic regression was used to model service receipts.

Principal Findings. These practice characteristics were significantly associated with patient-specific receipt of radiographic services: number of different practices attended during follow-up; dentist's rating of how busy the practice was; typical waiting time for a new patient examination; practice size; percentage of patients that the dentist reported as interested in details about the condition of their mouths; percentage of African American patients in the practice; percentage of patients in the practice who do not have dental insurance; and dentist's agreement with a statement regarding whether patients should be dismissed from the practice. Effects had differential magnitudes and directions of effect, depending upon radiograph type.

Conclusions. Practice characteristics were significantly associated with patient-specific receipt of services. These effects were independent of patient-specific disease level and patient-specific sociodemographic characteristics, suggesting that practitioners do influence receipt of these diagnostic services. These findings are consistent with the conclusion that practitioners act in response to a mix of patients' interests, economic self-interests, and their own treatment preferences.

Key Words. Practice characteristics, practice pattern, health care utilization, dental, race

Research on the influence that health care providers have on the variation in health care service receipt suggests several possible mechanisms by which this variation can occur (Wilensky and Rossiter 1983; Eisenberg 1985; Westert and Groenewegen 1999; Davis et al. 2000a; Long 2002; Grytten and Sørensen 2003). Early research proposed that variation could be attributed to physicians' preferences for and beliefs about effectiveness of particular procedures—or practice style—which are especially manifest where professional uncertainty exists (Wennberg, Barnes, and Zubkoff 1982; Eisenberg 1985). Others have concluded that variation results from providers operating in their patients' best interests, or in the providers' own economic self-interest, or in response to a range of constraints or incentives from patients, other colleagues, or health care organizations (Wilensky and Rossiter 1983; Westert and Groenewegen 1999; Davis et al. 2000b; Landon et al. 2001; Wennberg 2002; Long 2002; Grytten and Sørensen 2003).

Dental care offers several advantages for investigating practice variation. The sector itself comprises a significant part of health care overall and treats multiple conditions (ranging from those that would be apparent to patients, to those that would only be evident to a clinician). The sector also provides multiple types of diagnostic and treatment services, ranging from services that all clinicians would agree on (e.g., excision of a pathologic lesion), to multiple treatment options for the same clinical circumstance (e.g., options to restore missing teeth), to treatment that is performed for entirely discretionary reasons (e.g., for esthetic reasons). Only a very limited amount of research has been conducted on practice variation in dental care, but this research has found that substantial variation also exists there (Bailit and Clive 1981; Grembowski, Milgrom, and Fiset 1991; Bader and Shugars 1995). Grembowski, Milgrom, and Fiset (1990) found that dental service variation was associated with dentists' practice characteristics, but because patient-level measures of clinical need were not available, they could make no statements about whether this was due to patient variation, undertreatment, or overtreatment.

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Typically, practice variation studies—dental and medical—have either not been able to account for patient characteristics or have only been able to do so at the practice level. This distinction is important because patient-level data are usually necessary to avoid making incorrect conclusions about practice variation (Diehr et al. 1990). One of the major advantages of the study in this report, the Florida Dental Care Study (FDCS), is that it provided both patient-level and practice-level data. The FDCS was a prospective observational cohort study of oral health and dental care that used a racially and socio-economically diverse community-based sample of participants without regard to these adults' past dental care use (Gilbert, Duncan, Kulley et al. 1997; Gilbert, Duncan, Heft, and Coward 1997; Gilbert, Duncan, Heft et al. 1998; Gilbert, Duncan, and Vogel 1998; Gilbert, Rose et al. 2002; Gillbert, Shah et al. 2002; Gilbert, Duncan, and Shelton 2003; Gilbert, Shelton et al. 2003; Gilbert, Coke et al. 2004). The focus of this report is on receipt of dental diagnostic radiographic (X-ray) procedures.

Some studies have proposed hypothetical scenarios and requested that dentists make recommendations about whether dental radiographs should be taken (Matteson et al. 1983; Kaugars, Broga, and Collett 1985; Mileman et al. 1988; Swan and Lewis 1993). Although much has been learned from these studies, one limitation has been that these studies queried what dentists would recommend in a hypothetical circumstance. To our knowledge, no study has reported on the role of practice characteristics in receipt of dental radiographs, with the additional capability of being able to account for patient-level differences in clinical need and sociodemographic circumstance. Therefore, our objectives were to test hypotheses that—with patient-level characteristics accounted for—the following practice characteristics are significantly associated with receipt of dental radiographic procedures: (1) practice setting; (2) patient population served; (3) dental procedure characteristics; and (4) dentist's individual characteristics.

METHODS

Sampling Methods

FDCS sampling methodology details are provided elsewhere (Gilbert, Duncan, Kulley et al. 1997). Briefly, the 873 baseline subjects comprised a representative sample of persons 45 years or older, who had a telephone, did not reside in an institutional setting, resided in four counties in north Florida, could engage in a coherent telephone conversation, and had at least one tooth (one objective was to investigate tooth loss). At baseline, the sample's "interval

since last dental visit” was very similar to National Health Interview Survey (NHIS) data; conclusions about determinants of that interval were the same. Also, the percentage that had at least one dental visit in the first 2 years (77 percent) was very similar to the figure (75 percent) among comparable NHIS respondents (Bloom, Gift, and Jack 1992; Gilbert, Duncan, Kulley et al. 1997).

Although the study began with 873 participants, by 48 months 85 percent (weighted $n = 743$; unweighted $n = 714$) remained. The issue of bias due to attrition has been addressed in detail in previous reports (Gilbert, Duncan, Heft et al. 1998; Gilbert, Duncan, and Vogel 1998; Peek et al. 1999). Briefly, however, as an example of its typical magnitude, 47 percent of baseline participants had been to a dentist in the previous six months. If the baseline had only included persons who ultimately participated for the 48-month interview, that figure would have been 49 percent.

Data Gathering Stages

An in-person interview and clinical dental examination were conducted at baseline. This was followed by telephone interviews at 6, 12, 18, 30, 36, and 42 months. At 24 and 48 months, the interview was performed in-person, and was followed immediately by the clinical examination. Examination diagnostic criteria and examiner reliability have been detailed previously (see <http://nersp.nerdc.ufl.edu/~gilbert/manuscripts.htm>). Participants were asked for permission to review their dental records. Of the 297 dentists in 286 practices named by subjects through 48 months, all but 10 practices participated. There were 32 group practices: 25 with two dentists each, six with three dentists, and one with five dentists. Thirty-one dentists reported working at multiple practices: 28 reported working at two practices and three reported working at three practices. Dental chart data collection did not begin until after all participants had completed their 48-month interview. Of the 718 (weighted n) participants who ultimately reported having had at least one dental visit during the first 48 months of the study, we located complete chart data on 623 (weighted n), and 513 (weighted n) of these had dentists who completed a practice characteristics questionnaire. We compared person-level characteristics found to be relevant to radiographic service use (Gilbert, Coke et al. 2004) for persons who had complete data to those who did not. Persons with complete data were more likely to have been white (74 percent of whites with complete data, 62 percent of African Americans; χ^2 test, $p < .05$), and more likely to have reported the following reason(s) for dental visits: check-ups, loose cap or bridge, broken tooth, infected or sore gums, toothache, or broken filling (analysis of variance,

GLM procedure, $p < .05$). The two groups did not differ with regard to baseline number of root fragments, number of teeth, approach to dental care (regular versus problem-oriented attender), ability to pay an unexpected \$500 dental bill, or bleeding gums as a reason for dental visits. Additionally, the two groups did not differ based on age group, gender, or baseline rating of quality of dental care. Practices that were included in this report saw a mean of 3.6 FDSCS participants each. Practices that were not included saw a mean of 2.4 FDSCS participants each. There was not a significant difference between included and not-included practices in the number of patients seen ($p = .13$; Wilcoxon's rank sums test).

We abstracted information on all dental treatment received during follow-up. Methodologic details have been published previously (Gilbert, Rose et al. 2002). Briefly, however, we recorded dates of visits, dentist name for a given visit, teeth or areas treated, procedure codes (ADA 1994), among others.

Coding of Radiographic Procedures

To understand how practice characteristics might influence radiograph receipt, a description of these procedures is warranted. A *periapical radiograph* (PA) is taken to view only one or two teeth and the bone immediately surrounding these teeth. Although image resolution is high, the disadvantage is that only one or two teeth are in view. The fee for one PA radiograph is about one-fifth the fee of a full-mouth series of X-rays (FMX). Having at least one PA was classified from ADA codes 0220 or 0230.

A *bitewing radiograph* (BWV) radiograph is taken to view the crowns of the teeth only, allowing for detailed detection of early dental decay and to assess periodontal bone height. Four exposures are typically taken to allow for views of all the teeth in the back of the mouth (posterior teeth). The fee for a set of four BWVs is about one-half the fee of an FMX. The advantages of BWVs are the detailed image resolution and the possibility of limiting the radiographic survey to only four exposures for a specific purpose (usually to detect early dental decay and to assess periodontal bone height). The disadvantage is that only posterior teeth are covered, and only parts of these teeth are imaged (this precludes radiographic diagnosis of pathology at the tooth's root tip, surrounding bone, or related areas). Having at least one BWV was classified from ADA codes 0270, 0272, or 0274.

An *FMX* is a series of typically 21 individual radiographs of high resolution that image the full tooth and surrounding bone. The main advantage of the FMX is the substantial detail allowed from its high resolution. This allows

for a detailed assessment of treatment needs and treatment planning. An FMX comprises four BWX exposures and 17 PA exposures, so an additional advantage is that its per-image fee is much less because its 21 images are bundled into a single fee. Disadvantages include the multiple exposures required and the higher overall fee. An FMX was classified from ADA code 0210.

A *panoramic radiograph* (PAN) exposes in a single radiograph all the teeth and much of the oral-facial complex. The film is exposed entirely outside the mouth and requires a different machine from the one used to expose PA, BWX, or FMX radiographs. The PAN machine costs about 10 times the amount to purchase a machine to expose FMX radiographs. The main advantage of a PAN exposure is its broad image coverage; a disadvantage is its modest resolution, preventing detailed views. The fee charged a patient for a single PAN film is typically the same as that of an FMX (fees charged by FDCS dentists are available at <http://nersp.nerdc.ufl.edu/~gilbert/xrayfees.html>). A PAN was classified from ADA code 0330.

Questionnaire Content

Participants were asked about past dental care, dental attitudes, oral hygiene habits, dental diseases and conditions, and sociodemographic circumstance. Questionnaire content and test-retest reliability of questions have been described previously (Gilbert, Duncan, Heft, and Coward 1997; Gilbert, Duncan, Heft et al. 1998; Gilbert, Duncan, and Vogel 1998). Dentists who served one or more FDCS participants were asked to complete an 11-page questionnaire about characteristics of their practices. The questionnaire queried items listed in Table 1. Questionnaire test-retest reliability estimates with 10 dental faculty at the University of Florida and 10 dentists in private practice outside of the four-county FDCS area. Depending upon the measurement scale, κ values exceeded 0.70 and intraclass correlation coefficients exceeded 0.83 for all items. Complete wording of all FDCS questionnaire items can be viewed at the Internet site listed in the Acknowledgments section.

Statistical Methods

Results were weighted using sampling proportions to reflect the population of interest (Gilbert, Duncan, Heft et al. 1997). Because persons could receive more than one service, statistical tests incorporated correlations between the four service types (FMX, PAN, BWX, or PA) and factors (namely, practice characteristics) associated with them (GENMOD; SAS Institute 2004). Statistical testing utilized simultaneous regression equations for the four binary outcomes (FMX, PAN, BWX, or PA) implemented with a multivariate (four

Table 1: Practice Characteristics Tested for Their Association with Radiographic Service Receipt

<i>Practice Setting</i>	<i>Patient Population</i>	<i>Dental Procedure Characteristics</i>	<i>Dentist's Individual Characteristics</i>
Number of different general practices attended during follow-up*	Dental insurance coverage	Percent of extracted teeth that are replaced by specified treatment options (5 total [§])	Year of graduation from dental school
Number of different specialty practices attended during follow-up*	Practice charges by payment source	Number patients each month receiving or referred for dental extractions	Agreement with beliefs about treatment options (5 total)
Practice busyness [†]	Percent of patients on extended payment schedules	Percent time each day doing specified procedure categories (7 total [¶])	
Waiting time for new patient exam	Percent of patients who have certain characteristics (12 total [‡])		
Waiting time for restorative dentistry appointment	Age distribution		
Waiting time after arriving in waiting room	Racial/ethnic distribution		
Percent of visits due to unscheduled care			
Number of patient visits each week			
Hours in patient care each week			
Number of dental chairs regularly used			
Number of full-time staff			
Number of part-time staff			

*Although this variable can also be conceptualized as a patient-specific characteristic, we have operationalized it herein as a measure of practice setting because it reflects exposure to different sets of practice characteristics.

[†]1, (too busy to treat all people requesting appointments; 2, provided care to all who requested appointments, but the practice was overburdened; 3, provided care to all who requested appointments, and the practice was not overburdened; 4, not busy enough – the practice could have treated more patients.

[‡]Percent of patients you see who: seek care soon enough; fear dentists; complain about waiting; pay their bills; follow advice about oral hygiene; show for appointments as scheduled; take responsibility for their oral health; treat me with the respect that I deserve; want to know details about the condition of their mouths; want to know details about their treatment options; use credit cards to pay for their dental treatment in my practice.

[§]For extractions that you do or recommend, other than wisdom teeth, deciduous teeth, or for orthodontic reasons, what percent are replaced eventually by a: fixed bridge; removable partial or full denture; dental implant; not replaced; other.

[¶]Percent of patient contact time that you spend in a typical month performing the following procedures: nonimplant restorative dentistry (fillings, etc.); implants (either implant surgery or time spent with implant placement); removable prosthodontics (dentures); dental extractions; periodontal therapy (either time spent doing surgery or with nonsurgical procedures); endodontic therapy (root canals, etc.); other (preventive and diagnostic).

^{||}Patients should seek second opinions; patients are better off not knowing all the facts about their oral problems; dentists should present all treatment options to patients; if a patient opposes the dentist's recommended treatment, the dentist should try to convince the patient to accept it; if a patient does not accept the dentist's recommended treatment, the patient should be dismissed from the practice (1, very strongly disagree; 2, strongly disagree; 3, somewhat disagree; 4, somewhat agree; 5, strongly agree; 6, very strongly agree).

outcomes) multivariable (multiple explanatory covariates) logistic regression model. Because a factor (e.g., number of practices attended) could lead to more than one type of radiographic procedure, valid statistical testing required that the four service types be tested simultaneously. This is in contrast to performing separate statistical tests (i.e., logistic regressions) for each of the four service types, which would preclude direct comparison of parameter estimate magnitudes, and which would not provide an overall test of significance. We used a *SAS* macro to implement this testing (Shelton et al. 2004).

A note regarding the stepwise nature of our modeling technique is warranted. We adopted stepwise variable selection in blocks for the sake of parsimony because we had multiple measures of practice characteristics. For initial variable selection, we adopted a less stringent criterion for statistical significance, $p < .10$. Evaluation of the final model used $p < .05$ as the criterion for statistical significance. Because our previous work (Gilbert, Coke et al. 2004) suggested that patient-specific factors were important, each regression step also included these factors: reason(s) for dental visit(s), baseline clinical characteristics, and certain sociodemographic characteristics, requiring that practice characteristics be salient after accounting for patient-specific factors. The first block tested the practice setting characteristics shown in Table 1. Those that met the $p < .10$ criterion were retained, and were consequently included in all subsequent steps. Subsequent steps included the domains (patient population, dental procedure characteristics, dentist's individual characteristics) in the order shown in Table 1. Variables that met the $p < .10$ criterion were retained in later steps. The final step retained only the variables shown in Table 3.

RESULTS

Overall, a total of 25 percent of participants received an FMX at least once during follow-up, compared with 18 percent for a PAN, 57 percent for a BWX, and 55 percent for a PA. The one characteristic not determined from the dentist questionnaire was the number of general dentistry practices attended during follow-up (one practice [$n = 418$]; two [$n = 73$]; or three [$n = 23$]). A total of 22 percent of participants who attended one practice received an FMX, compared with 30 percent for those who attended two practices, and 58 percent for those who attended three ($p < .05$; tested using a single multivariate outcome-univariable predictor logistic regression). A total of 51 percent of participants who attended one practice received a PA, compared with 69 percent for those who attended two practices, and 75 percent for those who

attended three ($p < .01$). The number of general practices attended was not significantly associated with receipt of a PAN or BWX.

Results from the practice characteristics determined by dentist questionnaire are shown in Table 2. Most of the measured characteristics were associated with at least one of the radiographic types.

Multivariate–Multivariable Logistic Regression Results

Table 3 shows the results of a single logistic regression in which receipt of the four radiographic procedure types was modeled simultaneously. Results are shown in four columns, corresponding to the four procedure types, and to aid interpretation, parameter estimates were converted to odds ratios (OR).

Eight practice characteristics were independently associated with receipt of certain types of radiographs (Table 3), with patient-specific variables (reason[s] for dental visit[s], baseline clinical characteristics, and sociodemographic characteristics) taken into account. The larger the number of dental practices attended, the higher the probability of having received an FMX (OR = 1.99) or PA (OR = 1.80). Participants who attended practices that were not as busy, were more likely to have received an FMX (OR = 1.63). The longer the typical waiting time for a new patient examination, the lower the probability of having received an FMX (OR = 0.96), but the larger the probability of having received a PA (OR = 1.02). The larger the number of dental chairs regularly used, the higher the probability of having received a PAN (OR = 1.12). The higher the percentage of patients in the practice who want to know details about the conditions of their mouths, as reported by the dentist, the lower the probability of having received a PAN (OR = 0.98; a procedure that provides less detail due to lower resolution than an FMX) or BWX (OR = 0.98; less detail than an FMX because it is limited to fewer teeth and does not image the entirety of those teeth). Independent of participant-specific race, participants who attended practices with higher percentages of African Americans were less likely to have received an FMX (OR = 0.98; making that person less likely to have received full diagnostic detail). Independent of participant-specific dental insurance coverage, participants who attended practices with higher percentages of patients without dental insurance were less likely to have received a BWX (OR = 0.97; a procedure typically covered by dental insurance). Participants who attended a practice in which the dentist more strongly agreed that patients should be dismissed from the practice if they do not accept the recommended treatment, were more likely to have received an FMX (OR = 1.51) and less likely to have receive a PA (OR = 0.65).

Table 2: Dental Practice Characteristics to Which FDACS Participants Were Exposed during Follow-up, by Whether or Not These Participants Received an FMX, PAN, BWX, or PA Radiograph at Least Once during Follow-up

<i>Dental Practice Characteristic</i>	<i>Mean (SD) Value of Practice Characteristic, by Whether or Not the Participant Received during Follow-up . . .</i>							
	<i>No FMX</i>	<i>An FMX</i>	<i>No PAN</i>	<i>An PAN</i>	<i>No BWX</i>	<i>An BWX</i>	<i>No PA</i>	<i>An PA</i>
Practice setting								
Practice business rating	2.1 (0.9)	2.8 (0.9)	2.3 (1.0)	2.1 (0.9)	2.2 (0.9)	2.3 (1.0)	2.3 (0.9)	2.3 (1.0)
Typical time a patient has to wait . . .								
For a new patient exam	23.3 (27.5)	9.0 (10.9)	19.1 (26.6)	23.2 (22.8)	23.9 (27.0)	16.8 (24.1)	17.1 (21.5)	21.1 (28.7)
appointment (in days)								
In waiting room (in minutes)	13.4 (9.5)	9.9 (8.1)	11.7 (9.3)	16.4 (8.3)	13.2 (8.4)	12.1 (10.2)	12.5 (9.9)	12.6 (8.8)
For a restorative dentistry	19.8 (22.4)	9.0 (9.3)	15.9 (19.1)	22.7 (26.7)	19.3 (22.1)	15.5 (19.8)	15.8 (21.6)	18.2 (20.5)
appointment (in days)								
Percent of visits in practice	9.7 (10.5)	7.6 (6.3)	8.9 (9.0)	10.8 (12.6)	10.4 (11.0)	8.3 (8.5)	7.6 (8.7)	10.5 (10.6)
because of unscheduled care								
Number of patient visits each	58.3 (26.0)	51.9 (37.7)	54.2 (27.8)	68.5 (30.0)	60.5 (30.9)	53.9 (26.0)	54.7 (30.1)	58.4 (27.7)
week done by dentist								
Number of hours each week in	32.5 (6.3)	30.3 (10.7)	32.1 (7.3)	31.0 (8.0)	31.3 (8.2)	32.4 (6.6)	31.1 (7.9)	32.6 (7.1)
direct patient care								
Number of dental chairs	4.6 (2.9)	4.5 (2.8)	4.4 (2.5)	5.6 (4.0)	5.2 (3.6)	4.2 (1.7)	4.3 (2.3)	4.9 (3.2)
regularly use								
Number of full-time staff	3.8 (2.0)	4.3 (2.3)	3.8 (2.1)	4.4 (2.1)	4.1 (2.3)	3.7 (1.7)	3.6 (1.9)	4.1 (2.2)
Number of part-time staff	2.1 (1.5)	2.1 (1.5)	1.9 (1.4)	2.7 (1.9)	2.4 (1.7)	1.7 (1.1)	1.9 (1.4)	2.2 (1.6)
Patient population								
Percent of patients who are . . .								
Covered by a private insurance	51.2 (21.4)	52.5 (26.6)	52.3 (22.8)	47.7 (21.0)	45.7 (22.9)	55.8 (20.8)	51.9 (22.9)	51.1 (22.2)
program								
Covered by a public program	12.1 (13.1)	5.6 (10.8)	9.3 (12.0)	16.2 (15.4)	11.4 (12.3)	9.8 (13.7)	9.4 (13.0)	11.4 (13.0)
Not covered by any third party	34.4 (20.9)	36.5 (22.7)	35.4 (21.3)	32.5 (21.1)	40.1 (21.4)	31.0 (20.0)	35.0 (21.5)	34.8 (21.1)
and pay own bills								

Not covered and receive free or reduced-fee care	2.2 (4.5)	3.0 (9.0)	2.2 (4.7)	3.5 (8.5)	1.8 (3.5)	2.8 (7.3)	2.3 (5.4)	2.4 (5.9)
Percent of practice charges derived from...	52.4 (19.2)	47.7 (23.6)	51.8 (20.4)	48.9 (19.8)	47.0 (20.9)	54.4 (18.8)	50.8 (21.9)	51.6 (18.8)
Dental insurance	40.2 (19.2)	44.5 (23.4)	41.1 (20.0)	41.8 (20.9)	45.2 (21.2)	38.3 (18.4)	41.7 (21.5)	40.9 (19.1)
Self-pay	5.2 (6.0)	3.2 (4.3)	4.3 (5.5)	6.4 (6.7)	4.1 (5.0)	5.1 (6.5)	4.5 (5.4)	4.9 (6.1)
Unpaid bills	1.9 (6.4)	0.9 (4.8)	1.5 (5.3)	2.6 (8.8)	2.4 (6.9)	1.1 (5.2)	1.8 (7.5)	1.6 (4.8)
Other	12.9 (18.6)	20.1 (32.6)	15.8 (23.4)	9.5 (16.4)	14.0 (22.3)	15.2 (22.3)	14.0 (22.1)	15.2 (22.4)
Percent of patients on extended payment schedules								
Percent of patients who...								
Seek care soon enough	57.3 (21.1)	65.6 (23.6)	61.8 (20.8)	47.7 (22.5)	56.4 (23.8)	61.5 (19.3)	61.3 (23.6)	57.7 (20.3)
Fear dentists	38.1 (28.7)	34.0 (27.0)	34.2 (27.3)	50.5 (28.9)	41.9 (27.4)	33.5 (28.8)	34.4 (29.2)	39.2 (27.6)
Complain about waiting	5.0 (12.1)	7.6 (11.3)	4.8 (9.6)	9.7 (18.1)	7.6 (14.4)	4.1 (8.3)	6.3 (15.2)	5.1 (8.5)
Pay their bills	83.2 (27.7)	89.6 (17.3)	86.5 (23.5)	76.9 (33.6)	87.4 (22.4)	82.8 (29.5)	86.1 (25.3)	83.7 (26.8)
Follow advice about dental hygiene	52.8 (21.9)	58.0 (27.7)	55.1 (24.2)	49.6 (18.7)	49.1 (23.2)	57.7 (22.5)	56.2 (25.6)	52.3 (21.0)
Show for appointments as scheduled	85.5 (7.4)	84.9 (16.9)	85.8 (10.4)	83.5 (8.3)	85.0 (9.9)	85.6 (10.2)	85.1 (12.5)	85.5 (7.5)
Take responsibility for their oral health	63.8 (21.9)	76.2 (21.1)	68.7 (21.3)	58.2 (24.9)	64.6 (22.0)	68.5 (22.8)	69.4 (23.3)	64.8 (21.5)
Treat me with the respect that I deserve	83.5 (27.7)	91.3 (17.6)	87.3 (23.5)	76.8 (33.8)	86.8 (22.0)	84.4 (30.0)	85.8 (25.7)	85.1 (26.7)
Want to know details about condition of their mouths	66.0 (28.1)	77.6 (25.7)	70.7 (27.8)	60.0 (27.5)	69.9 (25.8)	68.0 (30.3)	71.2 (27.6)	66.9 (28.4)
Want to know details about their treatment options	71.4 (24.4)	79.1 (23.7)	73.5 (25.2)	72.4 (21.8)	75.6 (23.9)	71.6 (25.1)	74.2 (25.0)	72.5 (24.1)
Use credit cards to pay for their dental treatment	18.5 (13.5)	21.5 (16.1)	18.2 (13.5)	24.3 (15.3)	17.7 (11.8)	20.4 (16.0)	19.0 (15.0)	19.4 (13.3)
Percent of patients who are... 1-18 years old	15.4 (6.7)	12.4 (9.0)	14.5 (7.3)	15.4 (7.7)	14.0 (7.1)	15.2 (7.6)	14.2 (7.4)	15.1 (7.3)

continued

Table 2. Continued

<i>Dental Practice Characteristic</i>	<i>Mean (SD) Value of Practice Characteristic, by Whether or Not the Participant Received during Follow-up ...</i>							
	<i>No FMX</i>	<i>An FMX</i>	<i>No PAN</i>	<i>An PAN</i>	<i>No BWX</i>	<i>An BWX</i>	<i>No PA</i>	<i>An PA</i>
19-44 years old	30.2 (9.3)	28.8 (11.2)	29.6 (9.5)	31.1 (10.6)	30.5 (8.9)	29.4 (10.5)	29.4 (10.4)	30.4 (9.1)
45-64 years old	35.5 (9.3)	35.8 (13.7)	35.5 (10.5)	36.0 (9.4)	35.9 (9.7)	35.3 (10.9)	36.0 (11.5)	35.2 (9.3)
65 years old or older	18.8 (9.2)	20.5 (10.9)	19.7 (9.5)	17.1 (10.0)	18.9 (8.5)	19.5 (10.7)	19.2 (9.7)	19.3 (9.6)
Percent of patients who are ...								
Non-Hispanic white	63.1 (16.7)	67.4 (24.1)	65.1 (18.6)	59.8 (17.6)	61.5 (19.0)	66.2 (17.6)	64.7 (20.4)	63.7 (16.7)
Non-Hispanic black	31.5 (16.6)	22.2 (18.5)	28.0 (17.5)	34.6 (16.5)	31.6 (18.1)	27.3 (16.5)	28.6 (19.0)	29.7 (16.2)
Hispanic	3.2 (3.9)	4.6 (5.2)	3.6 (4.1)	3.4 (4.9)	3.6 (3.9)	3.5 (4.6)	3.0 (3.9)	4.0 (4.4)
Of Asian descent	1.8 (2.5)	3.0 (3.9)	2.2 (3.0)	2.0 (2.3)	2.3 (2.8)	2.0 (2.9)	1.9 (3.0)	2.3 (2.8)
Of other ethnicity	0.3 (1.3)	0.3 (1.2)	0.3 (1.3)	0.3 (0.8)	0.1 (0.7)	0.4 (1.6)	0.1 (0.9)	0.4 (1.5)
Dental procedure characteristics								
For dental extractions ... what percent are replaced eventually by ...								
A fixed bridge	27.8 (22.8)	39.6 (25.7)	31.3 (24.1)	27.3 (23.1)	28.0 (22.3)	32.6 (25.3)	31.3 (24.9)	30.1 (23.1)
A removable partial or full denture	32.4 (17.2)	25.1 (17.5)	30.8 (17.0)	29.9 (19.5)	32.5 (16.8)	29.2 (18.1)	31.2 (19.5)	30.1 (15.8)
A dental implant	3.1 (6.9)	6.0 (11.2)	3.8 (8.0)	4.0 (8.3)	3.9 (8.4)	3.7 (7.6)	3.7 (8.3)	3.9 (7.8)
Not replaced	36.7 (21.7)	25.7 (20.7)	33.1 (21.9)	38.6 (22.2)	34.6 (20.1)	33.6 (24.0)	32.4 (21.1)	35.4 (22.8)
Other	0.0 (0.3)	0.1 (0.9)	0.1 (0.5)	0.0 (0.0)	0.0 (0.2)	0.1 (0.6)	0.1 (0.5)	0.0 (0.4)
Number of dental extraction patients each month	26.9 (20.9)	17.7 (20.0)	23.0 (19.6)	32.1 (25.8)	28.0 (22.5)	22.1 (19.3)	22.5 (19.6)	26.4 (22.2)
Percent patient contact time dentist spends doing ...								
Nonimplant restorative dentistry	55.9 (22.2)	57.4 (24.9)	58.1 (22.0)	47.6 (23.7)	51.7 (24.3)	59.7 (20.1)	58.9 (23.7)	54.1 (21.7)
Dental implants (surgery or prosthetic time)	1.1 (2.0)	3.0 (8.8)	1.6 (4.8)	1.2 (1.9)	1.7 (5.6)	1.4 (2.6)	1.0 (2.1)	2.0 (5.5)
Removable prosthetics	12.7 (17.6)	10.1 (8.0)	11.0 (12.8)	16.9 (24.9)	16.2 (20.8)	8.9 (7.1)	11.3 (14.7)	12.6 (17.3)
Dental extractions	10.1 (7.5)	7.4 (7.3)	9.0 (7.5)	11.7 (7.6)	10.4 (7.7)	8.7 (7.3)	9.1 (7.8)	9.7 (7.4)

Periodontal therapy (surgical and nonsurgical)	3.8 (5.2)	3.2 (4.8)	3.6 (5.3)	3.7 (4.4)	3.6 (4.2)	3.6 (5.9)	2.8 (4.2)	4.3 (5.6)
Endodontic (surgical and nonsurgical)	8.1 (7.6)	5.5 (6.2)	6.6 (6.7)	11.2 (8.7)	6.0 (6.1)	8.5 (8.3)	6.1 (6.7)	8.6 (7.7)
Other (preventive and diagnostic)	8.5 (8.3)	10.6 (8.9)	9.3 (8.6)	7.6 (7.9)	9.6 (8.4)	8.5 (8.6)	9.5 (8.8)	8.6 (8.2)
Dentist's individual characteristics								
Last two figures of dentist's graduation year from dental school	74.2 (9.1)	71.1 (10.6)	73.4 (9.8)	73.7 (8.3)	73.9 (9.1)	73.1 (9.9)	73.5 (9.5)	73.5 (9.5)
Dentist's agreement with these statements...								
Patients should seek second opinions ...	4.2 (0.7)	4.0 (1.0)	4.1 (0.8)	4.0 (0.7)	4.2 (0.7)	4.1 (0.9)	4.1 (0.7)	4.1 (0.8)
Patients are better off not knowing all the facts ...	1.8 (1.1)	1.8 (1.2)	1.8 (1.1)	1.8 (1.2)	1.9 (1.2)	1.7 (1.1)	1.8 (1.3)	1.7 (1.1)
Dentists should present all treatment options ...	5.3 (1.0)	5.1 (1.3)	5.3 (1.1)	5.2 (1.1)	5.3 (1.0)	5.3 (1.2)	5.2 (1.0)	5.3 (1.1)
If a patient opposes recommended treatment, the dentist should try to convince the patient to accept it	3.4 (1.2)	3.6 (1.5)	3.5 (1.3)	3.4 (1.3)	3.4 (1.2)	3.4 (1.4)	3.3 (1.3)	3.6 (1.2)
If a patient does not accept recommended treatment, the patient should be dismissed ...	2.2 (0.9)	2.6 (1.3)	2.3 (1.0)	2.2 (1.0)	2.4 (0.9)	2.2 (1.1)	2.4 (1.0)	2.2 (1.0)

Values highlighted in bold and italic font indicate that the difference in mean values between persons who received the radiographic procedure and persons who did not is statistically significant, $p < .05$; tested using a multivariate (four outcomes) univariable (one explanatory covariate) GENMOD logistic regression for each characteristic.

FDCS, Florida Dental Care Study; FMX, full-mouth series of X-rays; PAN, panoramic radiograph; BWX, bitewing radiograph; PA, periapical radiograph.

Table 3: Results from a Single Multivariate Multivariable Logistic Regression of Receipt of FMX, PAN, BWX, or PA Radiographs

<i>Explanatory Variable</i>	<i>FMX</i>	<i>PAN</i>	<i>BWX</i>	<i>PA</i>
Practice setting				
Number of different general practices attended	2.15 (1.28, 3.60)	—	—	1.86 (1.06, 3.26)
Number of different specialty practices attended	2.62 (1.12, 6.12)	—	—	1.80 (1.05, 3.16)
Practice busyness	1.63 (1.04, 2.56)	—	—	—
Waiting time for a new patient examination	0.96 (0.94, 0.99)	—	—	1.02 (1.01, 1.03)
Number of dental chairs regularly used	—	1.14 (1.06, 1.22)	—	—
Patient population				
Percentage of patients who want to know details about mouth condition	—	0.98 (0.97, 0.99)	0.98 (0.97, 0.99)	—
Percentage of African American patients in the practice	0.98 (0.96, 0.99)	—	—	—
Percentage of patients without dental insurance	—	—	0.97 (0.96, 0.98)	—
Dentist's individual characteristics				
Agreement that patients should be dismissed	1.52 (1.10, 2.11)	—	—	0.63 (0.49, 0.81)

Parameter estimates were converted to odds ratios along with their 95% confidence intervals. $n = 512$, deviance value = 1.06/df. This regression also includes reason(s) for dental visits, baseline clinical characteristics (had a root fragment, number of teeth), and sociodemographic characteristics (race, ability to afford an unexpected \$500 dental bill, and regular versus problem-oriented approach to dental care), but these are not shown for ease of presentation. The rationale for including the variables not shown, and their exact coding, are detailed in Gilbert, Coke et al. (2004).

Coding of outcomes of interest:

- FMX: 1, had one or more FMXs during follow-up; 0, did not.
- PAN: 1, had one or more PANs during follow-up; 0, did not.
- BWX: 1, had one or more BWXs during follow-up; 0, did not.
- PA: 1, had one or more PAs during follow-up; 0, did not.

Coding of explanatory covariates.

Number of different general practices attended: Range of one to three dentists among practices that served participants in the regression.

Number of different specialty practices attended: Range of one to three dentists among practices that served participants in the regression (truncated at 2).

Practice busyness during the past 12 months: 1, "too busy to treat all people requesting appointments"; 2, "provided care to all who requested appointments, but the practice was overburdened"; 3, "provided care to all who requested appointments, and the practice was *not* overburdened"; 4, "not busy enough – the practice could have treated more patients."

Waiting time for a new patient examination: "On average, how long does a patient in your practice have to wait for a new patient exam appointment?" Range of 0–120 days among practices that served participants in the regression.

Number of dental chairs regularly used: "How many chairs do you, your assistant(s), and hygienist(s) use regularly in your part of the practice?" Range of two to eight chairs among practices that served participants in the regression (truncated at 8).

Percentage of patients who want to know details about the condition of their mouths: Range of 0–100% among practices that served participants in the regression.

Percentage of African American patients in the practice: Range of 0–96% among practices that served participants in the regression.

Percentage of patients in the practice without dental insurance: Range of 0–90% among practices that served participants in the regression.

Agreement that patients should be dismissed: "If a patient does not accept the dentist's recommended treatment, the patient should be dismissed from the practice." 1, very strongly disagree; 2, strongly disagree; 3, somewhat disagree; 4, somewhat agree; 5, strongly agree; 6, very strongly agree.

FDCS, Florida Dental Care Study; FMX, full-mouth series of X-rays; PAN, panoramic radiograph; BWX, bitewing radiograph; PA, periapical radiograph.

These ORs are interpreted as changes in odds of service receipt for each one-unit difference in the explanatory covariate. Scales are not the same for all covariates and therefore could cause confusion when interpreting the magnitude of ORs for the variable overall. Consequently, these scales appear in Table 3. For example, the OR of receiving an FMX for each difference of one “general practice” attended was 2.15, with other factors taken into account. Therefore, the OR for three general dentistry practices versus one practice is 4.62 (2.15 squared). Because the scale was truncated at 2 for “specialty practices” (the next variable in Table 3), the OR of receiving an FMX for attending two specialty practices compared with only one specialty practice was 2.62. Regarding the next variable, (“practice busyness”), going from a practice that was “too busy. . .” to one that was “not busy enough . . .” is a 3-unit change that results in an OR of 4.33 (1.63 cubed). For “waiting time for a new patient examination,” the OR for a practice with 120 days waiting time versus one with 0 days waiting time is 0.01 (0.96 raised to the 120th power). The OR of receiving an FMX for each one-point increase in “percentage of African Americans in the practice” was 0.98. Therefore, going from a practice where the value was 10 percent to one with an 80 percent value results in an OR of 0.24 (0.98 to the 70th power), also a substantial effect size. Similar calculations should be carried out when interpreting OR for the PAN, BWX, and PA service receipt outcomes.

DISCUSSION

To our knowledge, this is the first study to demonstrate that practice characteristics are significantly associated with receipt of dental radiographs. We also are not aware of any studies that have reported on receipt of specific types of radiographs (distinguishing FMX, PAN, BWX, PA, etc.), to which to compare our results. Because a substantial amount of practice variation can be due to differences in the patient population served—sometimes leading to incorrect conclusions about the source of that variation (Diehr et al. 1990; Bader and Shugars 1995; Franks et al. 2003)—it is significant that these analyses accounted for patient-specific clinical characteristics and sociodemographic circumstance. Indeed, our earlier work (Gilbert, Coke et al. 2004) showed a very strong effect due to clinical and sociodemographic characteristics, lending further evidence that practice-level studies should account for patient-level differences between practices. Our finding that clinical characteristics are strongly associated with dentists’ variation in radiographic service rates, is

consistent with conclusions made using dentists' responses to hypothetical scenarios (Matteson et al. 1983; Mileman et al. 1988). These findings are consistent with the notion (i.e., a necessary but not sufficient condition) that dentists are appropriately tailoring radiographic prescription to the clinical needs and disease risk of their patients, instead of prescribing on a regimen based on the time since last radiographic examination or other nonclinical reasons, which would not be in accord with recommended practice guidelines.

Like physicians (Eisenberg 1985; Westert and Groenewegen 1999; Long 2002), dentists have the capability to influence the diagnostic and treatment process and therefore the uptake of these services (Grembowski, Andersen, and Chen 1989). Evidence for provider inducement in the medical context has been mixed (Davis et al. 2000a), and this notion of provider or supplier inducement has led to a substantial literature about the influence of physician "practice style" and to argument that a distinction should be made between physician-initiated demand and physician-induced demand, the former type being substantial, and the latter type being negligible (Wilensky and Rossiter 1983; Long 2002). Physician-initiated demand is manifested by procedures that are generally made for the benefit of uninformed clients, with physicians making decisions as patients' agents and in their patients' best interests (Wilensky and Rossiter 1983). Other research suggests that providers can and do induce demand for their own economic benefit (Eisenberg 1985). A small number of studies suggest that dentists can operate similarly, although conclusions have been mixed. A study of Norwegian dentists (Grytten 1991) observed supplier-inducement effects and concluded that dentists in areas of excess supply were able to maintain their workload by increasing demand for their services. In a later study by the same group (Grytten and Sörensen 2000), the Norwegian dentists did not exert their potential to exert competitive influences and the authors concluded that financial incentives are important, but these incentives are constrained by patient interests rather than by self-interest. A study conducted in Canada found that the volume and intensity of dental services increased when fee constraints were imposed on dentists (Porter et al. 1999)—an observed increase in periodontal services was a supply-side response to a reduction in reimbursement, not due to an increase in demand for services by patients. Birch found supplier-inducement effects on costs for dental services per visit provided under the British National Health Service (Birch 1988). In what to our knowledge is the only U.S. study, supplier-inducement effects were observed for specific dental services among children with dental insurance in Washington state (Grembowski and Milgrom 1988). Differences between the medical and dental contexts with regard to insurance

coverage may be relevant. For example, note that the percentage of patients without dental insurance was salient in Table 3. However, dental insurance coverage at the patient level was not salient in this sample (Gilbert, Coke et al. 2004).

If supplier inducement is operative in the dental context, then practice busyness and waiting time for a new patient examination should be related to uptake of services. Dentists may try to provide more services to each patient, rather than see more patients. This was indeed the finding in the FDCS. The fact that this was observed only for certain radiograph types is still consistent with the hypothesis because exposing an FMX would be a pre-requisite for complex and/or comprehensive treatment that would be costly. In what to our knowledge is the only other dental study related to practice busyness, practice busyness was found to be related to volume of prosthetic crown and bridge services, but not to diagnostic services (Grembowski, Milgrom, and Fiset 1991). However, in that study diagnostic services were aggregated to include all types of diagnostic services (radiographs or otherwise), and consequently did not disaggregate services into specific radiographic service types.

We are not aware of any reports that seeking care from a larger number of providers is associated with the probability of receiving diagnostic services; therefore, this is also the first report in the dental context. The reason for this strong association is not clear. A British study observed that the more dentists that patients visit, the more likely they are to have a dental restoration or filling replaced (Davies 1984). It is possible that these FDCS patients continued to search for a dentist until they found one who would take a diagnostic radiograph. It is also possible that seeing more dentists was associated with having more dental problems; however, this seems unlikely because dental problems were accounted for.

Patients who attended practices that regularly used a larger number of dental treatment chairs were more likely to have received a PAN. This variable may serve as a marker for practice size, consistent with the notion that use of PANs may be more common in larger practices (Kantor, Hunt, and Morris 1990). As might be expected, ownership of a PAN machine has been associated with whether PANs are included in typical radiographic prescription scenarios by dentists (Bohay, Stephens, and Kogon 1995), and based on data from non-U.S. dentists, a substantial minority of dentists do not own PAN machines (Tugnait, Clerehugh, and Hirschmann 2003). This circumstance could reflect the substantial expense of purchasing a PAN machine, as well as having a patient population that demands services that require a higher level of diagnostic detail and for which a PAN would therefore not be

advisable. Note in Table 2 that PANs were more likely in practices that reported that their patients do not seek care soon enough, fear dentists, do not take responsibility for their oral health, and do not want to know details about the condition of their mouths. These are all characteristics of patients whose clinical condition is more severe (typically requiring less radiographic diagnostic detail) and who demand services that do not require substantial radiographic detail. In a study of primary care medicine patients (Franks et al. 2003), patient effects were stronger for services that required patient initiative (e.g., mammography, diabetic eye examinations), whereas practice effects were stronger for services that required more physician initiative or discretion.

One limitation of the FDCS is that the sample was derived from four counties. Although we have demonstrated that this sample had much in common with what would have been derived from a comparable national sample (Bloom, Gift, and Jack 1992; Gilbert, Duncan, Kulley et al. 1997), studies from other populations are advisable, especially if one is interested in making inferences about geographic variations. It is also possible that patients self-select into practices based on patients' individual preferences, which then are reflected as differences at the practice level. Although we judge that the FDCS questionnaire and clinical examination provided comprehensive assessment of clinical and sociodemographic characteristics (Gilbert, Duncan, Heft, and Coward 1997; Gilbert, Duncan, Heft et al. 1998; Gilbert, Duncan, and Vogel 1998), it is possible that additional unobserved patient-level characteristics could have influenced our estimates of practice-level effects. Although clinical characteristics were taken into account, the issue of appropriateness of the radiographs taken was not specifically addressed in the data. An additional limitation is that we did not have sufficient statistical power to relate practice characteristics, clinical characteristics, and reason(s) for visits in single 6-month periods to radiograph receipt in the same 6-month period. Instead, we related characteristics to cumulative radiograph receipt during the 48-month follow-up period. One advantage of this approach is that we are able to associate a cumulative effect of predictors to a cumulative incidence of radiograph receipt, a cumulative effect that may operate on both the patient and the dentist that is distinct from a single effect within a given 6-month window of time. Future studies would ideally measure predictors on the day of radiographic receipt, although that approach would be cost-prohibitive in a population-based study.

This study suggests that, independent of patient-specific characteristics, certain dental practice characteristics are significantly associated with patient-

specific receipt of radiographic services. These findings underscore the distinction between what dentists hypothetically would prescribe based on responses to hypothetical scenarios when queried in questionnaires (Matteson et al. 1983; Kaugars, Broga, and Collett 1985; Mileman et al. 1988; Swan and Lewis 1993), compared with what is actually received. These results suggest that practitioners can and do influence receipt of diagnostic radiographic services, and are consistent with the notion that practitioners act in response to a combination of patients' interests, economic self-interests, and their own treatment preferences.

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