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The role of dentist, practice and patient factors in the provision of dental services

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Abstract – *Objectives:* Service provision varies by dentist, practice and patient factors. However, limited subsets of these potential influences on service rates have been explored. More comprehensive models could improve our understanding of the factors influencing the pattern of care delivered. The aim of this study was to examine variation in dental services by dentist (treatment choice, practice beliefs, preferences for patients, demographics), practice (type, location, size and volume of practice) and patient (visit, demographic, oral health and socio-economic) characteristics. *Methods:* A random sample of Australian dentists was surveyed in 1997–98 (response rate = 60.3%). Private general practitioners (n = 345) provided dentist and practice data, and service provision and patient variables were collected from a log of a typical clinical day (n = 4,115 patients). Multivariate negative binomial regression models were fitted for diagnostic, preventive, restorative, extraction and prosthodontic services. *Results:* Significant dentist factors included ($P < 0.05$; RR = rate ratio): lower diagnostic rates (RR = 0.78) for dentists with stronger practice beliefs for giving information about cost and treatment options; preventive rates were lower (RR = 0.74) for male dentists and higher (RR = 1.48) for younger dentists aged 20–29 years; restorative rates were higher (RR = 1.27) for dentists that rated patient preferences more highly in treatment choice and in the dentist age group 30–39 years (RR = 1.25); extraction rates were lower (RR = 0.61) for dentists with stronger preferences for patients that would adhere with treatment but higher (RR = 1.57) for dentists with stronger preferences for sociable patients; and prosthodontic rates were lower (RR = 0.38) for dentists with stronger preferences for adaptable patients who were willing to cooperate when expected to do so. Practice factors included: higher preventive (RR = 1.28) and prosthodontic rates (RR = 2.07) in solo practice; higher preventive (RR = 1.34) but lower prosthodontic rates (RR = 0.42) in capital cities; lower diagnostic (RR = 0.82) and extraction rates (RR = 0.55) in practices with fewer other dentists; higher diagnostic (RR = 1.33) and extraction (RR = 1.62) rates but lower restorative rates (RR = 0.84) in practices with lower patient visits per year. Patient factors included: lower preventive (RR = 0.76) but higher extraction rates (RR = 1.45) for emergency visits; lower extraction rates (RR = 0.60) for the insured; higher diagnostic rates (RR = 1.17) for new patients; higher restorative (RR = 1.31) but lower prosthodontic rates (RR = 0.46) for patients with decayed teeth; higher prosthodontic rates (RR = 2.14) for those with dentures; and lower preventive (RR = 0.66), but higher extraction (RR = 2.22) and prosthodontic rates (RR = 1.82) for patients from lower socio-economic status areas. *Conclusions:* Dental service rates were influenced by large number of small effects from a wide range of dentist, practice and patient factors. Socio-economic and geographic barriers may need broad policy innovations to be addressed, but factors such as insurance and visit type have the potential to be altered to achieve better service outcomes and there is scope for research into clinical outcomes to improve the knowledge upon which treatment decisions are based.

Key words: dental service rates; dentist factors; patient factors; practice factors; private general practice

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Variation in service provision has been observed for both medical and dental procedures (1–3), raising concerns in terms of appropriateness of care (4). Service provision has been related to a range of factors, spanning the dentist, practice and patient. While a range of investigations have attempted to explain the variation in service patterns, most studies have tended to model these factors separately or have included only a limited subset of the range of potential sources of influence on service patterns. More comprehensive models of the service provision process are required to improve our understanding of which factors are influencing the pattern of care delivered.

Models that can assess the extent to which dentist factors influence service patterns, after controlling for variation in practice and patient factors are necessary to extend our understanding of the process of service provision and the pattern of care provided. Dentist factors that have been suggested as sources of variation include dentists' practice beliefs (5), clinical decision making (i.e. diagnosis or detection, decision to intervene and selection of treatment) and the dentist–patient interaction (6). Variation in service rates has also been related to practice characteristics, such as size and busyness of practices (7), and practice age (5). Geographic location has also been associated with service patterns (8–10). Patient factors related to service patterns include age and sex (2, 10, 11), insurance (12–14) and emergency visits (15). The need to control for oral health status has been recognized (5). Patient-level factors such as non-emergency visits, dental insurance and socio-economic status have been related to variation in service rates, controlling for oral health status (16). These findings have shown that a range of factors in addition to oral health contributes to variation in service provision.

This paper addresses the issue of explaining variation in service rates by constructing service models incorporating a set of explanatory variables encompassing a range of dentist, practice and patient factors. A schematic model of the service provision process in Fig. 1 shows a pathway from oral health status to visit to provision of service and health outcome. Patients are linked to oral health and visit characteristics, and to a dentist who is linked to a practice. Dentists, practices and patients each have their own set of characteristics that may impact on the service provision process. The aim of this study was to examine factors associated with variation in dental service rates.

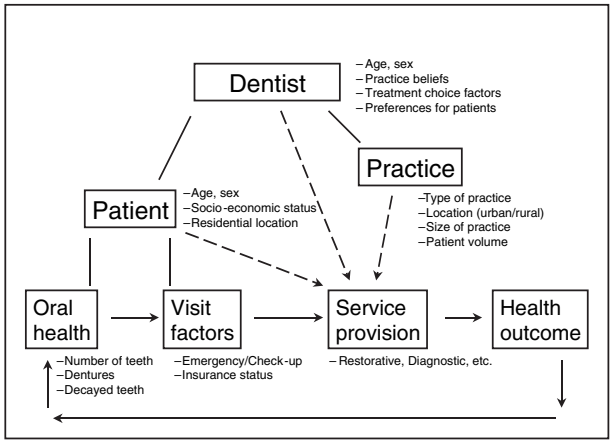

Fig. 1. Schematic model of service provision process.

Methods

Sample and response

In Australia, the majority of dentists are in private practice and most adult patients receive their dental care in the private sector (17). Most private patients must pay for their dental care, either directly or through individually purchased private dental insurance (15). Coverage of private dental insurance in Australia was 40.4% during 1994, and was positively associated with income (18). A random sample of 13.5% of dentists was drawn from the registers of each Australian State/Territory, resulting in a total sample of 1202 dentists. Sample size estimates were based on two-group comparisons of service rates to provide sufficient power to detect rate ratios of 1.50 in eight out of 10 main service areas and 1.75+ in all 10 areas. The target sample size of 1202 dentists was based on levels of response from similar surveys (8, 9, 11, 15) taking into account expected numbers of exclusions, percent working as private general practitioners and completion rates of service logs in order to provide sufficient numbers of patients (i.e. 4000+) for analysis from the service logs. Data on dentist, practice and patient factors (including oral health status and visit characteristics), and service provision were collected by self-complete mailed questionnaire during the 1997–1998 period (19). To maximize response rates primary approach letters, personalized names on cover letters, personally signed letters and multiple follow-up mailings to non-respondents were employed.

A total of 676 dentists responded to the survey, a response rate of 60.3% after excluding 81 dentists who were not in scope because they were not currently working in Australia or who could not be

contacted at their registered addresses. Of this total of 676, only 552 were entered for analysis, with the remainder being excluded for reasons such as ill health or retirement. Of the 552 entered responses, 451 were in general practice, with 418 in the private sector and 407 currently treating patients. Of the 407 private general practitioners currently treating patients, a total of 345 private general practitioners provided service log data from a typical clinical day. The characteristics of these dentists were compared with the 62 dentists who did not provide service logs to assess potential bias. These comparisons are presented in the Results section. The age distribution of the sample was not known, as the age of dentist is not listed on the published dental registers. However, the age and sex distribution of respondents can be compared with national data reported on the population of registered dentists to assess potential bias. This is presented in the Results section.

Data items

Dentists completed a questionnaire that comprised items dealing with both dentist and practice factors as well as a log of a typical day in which patient factors were recorded along with the services that were provided. The dentist factors consisted of dentist demographic characteristics such as age and sex, a set of 5-point Likert scales containing items relating to practice beliefs (5, 7) and dentist preferences for patients (20), and a set of six treatment choice scenarios (5, 21, 22). The treatment choice scenarios involved listing what factors were considered important in choosing between a visual examination versus radiographs, a preventive intervention versus restoration, crown versus amalgam or composite build-up, root canal versus extraction, fixed bridge versus removable partial denture and prophylaxis versus scaling. These were used to classify dentists by the factors they considered important in making treatment choices. Data reduction relating to the dentist factors of treatment choice, practice beliefs and dentist preferences for patients was performed prior to statistical testing, and has been reported in detail elsewhere. This involved cluster analysis of the responses to the treatment choice scenarios (23), and factor analysis and development of factor-based scales for the practice beliefs (24) and dentist preference items (25). The three mutually exclusive clusters of dentists based on treatment choice scenarios comprised: (i) Treatment choice driven by Patients (characterized by high values for patient factors such as 'patient preference'); (ii) Treatment choice driven by Constraints (high values for treatment constraints such as 'cost to patient'); and (iii) Treatment choice driven by Patients' Oral Health (high values for oral health factors such as 'mouth', 'tooth' and 'periodontal' status). The three scales relating to practice beliefs comprised: (i) Believe in Information Giving (comprising items such as 'dentists should usually inform patients about the cost of their dental treatment before treatment begins' and 'dentists should present all treatment options to patients'); (ii) Believe in Preventive Orientation (comprising items such as 'plaque control programs are a prerequisite for dental treatment'); and (iii) Believe in Giving Patient Influence (comprising items such as 'with the dentist's advice, the patient should choose the service'). Of these practice belief scales only Believe in Information Giving ($\alpha = 0.65$) had a reliability score approaching the minimum recommended level of 0.70, however all three scales were retained in the analysis for completeness. The four sub-scales relating to dentist preference for patients had adequate reliability (Cronbach's α: 0.71–0.90) and comprised: (i) Treatment Adherence Preference (behaviour relevant to the treatment situation – including items such as 'I prefer patients who': '… come in at recall', '… maintain their oral health' and '… follow instructions, e.g. for home care, other procedures'); (ii) Patient Adaptability Preference (willingness to cooperate when expected to do so – including items such as 'I prefer patients who': '… are content with the service provided', '… are patient' and '… are polite'); (iii) Patient Social Interactiveness Preference (positive affect, communicativeness and appreciativeness – including items such as 'I prefer patients who': '… are sociable', '… are charming' and '… are warm'); and (d) Patient Enabling Characteristics Preference (willing and able to pay, and good dental knowledge – including items such as 'I prefer patients who': '… have private insurance' and '… are able to afford optimal treatment').

Practice factors included type, location, size and volume of practice. Characteristics of patients treated during the 1-day log (e.g. age, sex) and visit details (e.g. insurance status, visit type) were recorded by the responding dentists at the time of service provision. Services provided during a typical day were collected using a 1-day log of services. Service items were recorded using the three-digit coding scheme from the Australian Dental Association's *Schedule of Dental Services* (26).

The number of patients sampled by each dentist during their 1-day log varied according to their typical level of activity. The data reported here are restricted to adult patients treated by private general practitioners. Dentists were free to choose which day to include in their service log. Dentists were instructed to record services for each patient treated regardless of whether or how they were charged to the patient. Patients were not identified, but were expected to make a single visit over the 1-day period of the log. Hence, visit comprised the unit of analysis, with the number of services provided in each area of service being expressed as a rate per visit, and entered in statistical models as the number of services divided by the number of visits. The sample of visits included in the 1-day log could include first, intermediate and final visits. These were not differentiated in the analysis as they were sampled at random and hence would provide a representative cross-section of these visit types.

Patient factors collected in the log included dentate status, whether the visit was for emergency care (i.e. relief of pain), dental insurance status, age of the patient, presence of decayed teeth, whether the patient was new to the practice, presence of dentures and residential postcode of the patient. The oral health variables of decayed teeth and denture wearing were recorded to indicate the status of each patient at the beginning of the current visit. Residential postcode of the patient was used to link with an area-based indicator of socio-economic status (SES) derived from census data (27). While area-based SES is often used as a proxy measure of individual SES it should be recognized that they are not necessarily the same and are best interpreted as indicating the extent to which neighbourhood characteristics explain service rates. The area-based SES index summarizes variables related to the economic resources of households, education and occupation. A higher score on the index suggests that the area has characteristics such as fewer families of low income, and fewer people with little training and in unskilled occupations. The index is designed to have an average of 1000 across all census collection districts in Australia and a standard deviation of 100, with 95% of cases within two standard deviations of the average (i.e. 800–1200). Patient factors were derived from the service log by summing the distribution of each variable and dividing by the total for each dentist (e.g. number of insured patients divided by the total number of patients), so that each patient factor (e.g. percentage of insured patients) was aggregated and then merged at the level of each dentist.

Data analysis

Analysis involved examination of the distributions of dependent (i.e. service rates) and independent (i.e. dentist, practice and patient) variables, testing of associations between service rates and the set of dentist, practice and patient variables, and construction of multivariate models of service rates by independent variables. No adjustment was made for multiple comparisons in the bivariate analysis. This was not necessary as all tests, both non-significant and significant, are presented (28).

Analyses of service rates by the independent variables were restricted to diagnostic, preventive, restorative, extraction and prosthodontic services, five of the 10 main areas of service. These areas were selected as diagnostic, preventive and restorative services were the dominant areas of services comprising the majority of all services provided and extraction and prosthodontic services were of public health significance in terms of their relevance to oral health outcomes associated with tooth loss.

Indicator variables (coded as 1, reference as 0) were used for all independent variables that were entered in multivariate regression models of service provision with number of services in each main area of service divided by the number of patient visits as the dependent variable. Continuous variables were converted into dichotomous variables prior to coding as indicator variables. Categorizing a continuous variable allows effects to estimated that are not constrained to any specific pattern (28), and the use of a dichotomous coding avoids potential problems associated with loss of statistical power where cells might be sparse or data poorly distributed that can be associated with inclusion of additional terms in a model to represent each variable. Scores on the strongly agree side of the midpoint were used for the dentist factors of practice beliefs and the dentist preference ratings for patients. The median was used as a cut-off point for the practice factors of number of dentists, waiting time, number of non-dentist staff and patients per year, and for all of the aggregated patient factors.

Models included main effects but interaction terms were not included. Interactions are difficult to detect unless their effects are large and there are sufficient subjects to cover the wide range of categories of the joint distributions of the variables involved, hence caution is advised in the

acceptance and interpretation of interactions (29). The analytic strategy of the paper was to build a comprehensive set of independent variables that could be compared across a range of service areas. The inclusion of interaction terms would have been unwieldy, especially in the absence of specific hypotheses regarding interaction. Non-significant terms were retained for comparability across the models, and their potential value in controlling for confounding (28). Service rates are typically skewed in their distribution (2). Poisson models are used extensively in applications dealing with counts of rare events (30). In general, the Poisson distribution performs more poorly than the negative binomial distribution when events are more likely to recur in some individuals than in others (31). A negative binomial distribution assumes each person uses dental procedures with a Poisson distribution, but that each person has a different Poisson parameter (32). Service rates were compared using rate ratios derived from the negative binomial regressions (33). A rate ratio of 1.0 indicates no difference in rate. A rate ratio above 1.0 indicates higher rates and those below 1.0 indicate lower rates in relation to the chosen reference category. As indicator variables were used the reference category was coded as 0 – see notes accompanying the multivariate analysis (Table 5) for details of each reference category. Pseudo R^2 values were reported for each model. Values of pseudo R^2 may range from 0 and 1, and are based on likelihood statistics from a model containing the independent variables versus a model containing a constant term only, rather than a comparison of fitted to observed values as obtained from linear regression models (34).

Ethical review

The research project was reviewed and approved by the Ethics Committee of the Australian Institute of Health and Welfare.

Results

Sample characteristics

There was a higher percentage of male (80.0%) than female dentists (20.0%), and the majority of responding dentists were in the age groups 30–39 (27.8%) and 40–49 (29.3%) years. Male dentists had an older age distribution than females, with higher percentages in the age groups 40–49 years (30.8% versus 23.2%), 50–59 years (20.3% versus 10.1%) and 60+ years (13.4% versus 0.0%). The responding dentists had a similar age distribution compared with the dentist population (17), with both distributions dominated by the 30–39 and 40–49 years age groups and male dentists having an older age distribution than female dentists. There were no significant differences between those dentists who supplied service data and responding dentists in the sample who did not provide service data by sex of dentist, age of dentist, practice type, geographic location, years since graduation, percent of time worked and number of other dentists in their main practice, practice activity measures (i.e. patients per hour, hours per year worked, patients per year and appointment time) and number of full-time equivalent support staff (i.e. assistants, hygienists, managers, secretaries and other staff). The responding private general practitioners collected data from a total of 4115 patients, with 11.9 ± 0.06 patients (mean ± SE) seen per dentist. The 4115 patients comprised 45.3% males and 54.7% females. The sample yield was sufficient to meet the power requirements outlined in the Methods section. Overall, there were small percentages of younger patients (aged less than 25 years) and older patients (aged 65+ years). The highest percentages of patients were aged 25–44 years (34.5%) and 45–64 years (30.6%). The age distributions were similar for male and female patients.

Distributions of service rates

The rate of services per visit in rank order across the 10 main areas of service comprised (mean ± SE): diagnostic (0.68 ± 0.02), restorative (0.64 ± 0.02), preventive (0.36 ± 0.02), endodontic (0.13 ± 0.01), prosthodontic (0.11 ± 0.02), crown and bridge (0.09 ± 0.01), extraction (0.09 ± 0.01), general/miscellaneous (0.05 ± 0.01), periodontic (0.02 ± 0.004) and orthodontic (0.004 ± 0.001). Further analysis was restricted to diagnostic, preventive, restorative, extraction and prosthodontic services, as outlined in the Methods section.

Distributions of dentist, practice and patient characteristics

Table 1 presents the distribution of dentist, practice and patient characteristics. Among the dentist factors: approximately half of the dentists were in the Treatment Choice driven by Patients' Oral Health cluster (51.7%), the majority of dentists had high belief ratings for the Believe in Information Giving (86.2%) and Believe in Giving Patient Influence (84.0%) scales but under half had high

Table 1. Distribution of responding dentists by dentist, practice and patient factors

Dentist factors	%	Practice factors[a]	%	Patient factors[b]	%
1. Treatment choice		*1. Type of practice*		*1. Visit details*	
Treatment choice driven by		Practice type		Emergency visits	
Patient cluster	24.6	Solo practice	50.8	Emergency visits: 0–30% of patients	67.6
Constraints cluster	23.7	Non-solo practice	49.2	Emergency visits: >30–60% of patients	25.1
Patients' Oral Health cluster	51.7			Emergency visits: >60% of patients	7.3
		2. Location of practice			
2. Practice beliefs		Geographic location		Insured patients	
Believe in Information Giving		Capital city	76.2	Dental insurance: 0–30% of patients	22.4
Higher belief rating (scale scores ≤2.0)[c]	86.2	Non-capital city	23.8	Dental insurance: >30–60% of patients	40.9
Lower belief rating (scale scores >2.0)[c]	13.8			Dental insurance: >60% of patients	36.7
		3. Size of practice			
Believe in Preventive Orientation		Number of other dentists		New patients	
Higher belief rating (scale scores ≤2.0)[c]	45.1	Work with no other dentists	29.7	New to practice: 0–30% of patients	85.3
Lower belief rating (scale scores >2.0)[c]	54.9	Work with 1 other dentist	37.8	New to practice: >30–60% of patients	12.8
		Work with 2 other dentists	14.7	New to practice: >60% of patients	1.9
Believe in Giving Patient Influence		Work with 3 or more other dentists	17.8		
Higher belief rating (scale scores ≤2.0)[c]				*2. Patient demographics*	
Lower belief rating (scale scores >2.0)[c]	84.0	Number of FTE non-dentist staff[d]		Patients aged 25–44 years	
	16.0	Work with 0–1 non-dentist staff	16.0	Age 25–44 years: 0–30% of patients	31.8
3. Dentist rating for patients		Work with >1–2 non-dentist staff	27.5	Age 25–44 years: >30–60% of patients	49.8
Treatment Adherence Preference		Work with >2–3 non-dentist staff	27.5	Age 25–44 years: >60% of patients	18.4
Higher preference (sub-scale scores ≤2.0)[c]	82.2	Work with >3 non-dentist staff	29.1		
Lower preference (sub-scale scores >2.0)[c]	17.8			*3. Patient oral health status*	
		4. Volume of practice		Patients with decayed teeth	
Social Interactiveness Preference		Waiting time for an appointment		Decayed teeth: 0–30% of patients	22.9
Higher preference (sub-scale scores ≤2.0)[c]	40.9	Waiting time of 0–1 days	14.0	Decayed teeth: >30–60% of patients	34.7
Lower preference (sub-scale scores >2.0)[c]	59.1	Waiting time of 2–3 days	29.3	Decayed teeth: >60% of patients	42.4
		Waiting time of 4–5 days	15.3		
Patient Adaptability Preference		Waiting time of six or more days	41.4	Patients with dentures	
Higher preference (sub-scale scores ≤2.0)[c]	79.2			Denture present: 0–30% of patients	73.0
Lower preference (sub-scale scores >2.0)[c]	20.8	Patient visits treated per year		Denture present: >30–60% of patients	25.2
		≤1200 patients per year	10.3	Denture present: >60% of patients	1.9
Patient Enabling Characteristics Preference		>1200–≤2400 patients per year	31.7		
Higher preference (sub-scale scores ≤2.0)[c]	23.4	>2400–≤3600 patients per year	36.5	*4. Socio-economic status (SES)*	

Table 1. Continued

Dentist factors	%	Practice factors[a]	%	Patient factors[b]	%
Lower preference (sub-scale scores >2.0)[c]	76.6	>3600 patients per year	21.5	Disadvantaged patients (SES index)	
				≤25% quantile for Australia (more disadvantaged)	13.8
				>25%–≤50% quantile for Australia	23.4
4. Dentist demographic characteristics					
Sex of dentist				>50%–≤75% quantile for Australia	22.1
Male	79.8			>75% quantile for Australia (less disadvantaged)	40.7
Female	20.2				
Age of dentist					
20–29 years	14.6				
30–39 years	28.0				
40–49 years	29.9				
50+ years	27.4				

[a]Main private practice.
[b]Dentate patients aged 18 years or more from service log.
[c]Scores range from 1.0 to 5.0 based on Likert scale responses of 1 = strongly agree to 5 = strongly disagree with the component items.
[d]FTE (full-time equivalent) staff based on 38 h per week.

ratings for the Believe in Preventive Orientation scale (45.1%), the majority of dentists had high ratings for the Treatment Adherence Preference (82.2%) and Patient Adaptability Preference (79.2%) scales but under half had high ratings for the Patient Social Interactiveness Preference (40.9%) and Patient Enabling Characteristics Preference (23.4%) sub-scales, the majority of dentists were male (79.8%) and the youngest age group comprised the smallest percentage of dentists (14.6%). Among practice factors: approximately half the dentists were in solo practice (50.8%), the majority were in capital city locations (76.2%), 29.7% worked with no other dentists, 16.0% worked with one or less full-time equivalent non-dentist staff, 41.4% had a waiting time for an appointment of six or more days, and over half the dentists provided over 2400 patient visits per year. Among the patient factors: the majority of dentists (67.6%) had 0–30% of patients attend for emergency visits, over one-third of dentists (36.7%) had greater than 60% of patients with dental insurance, the majority of dentists (85.3%) had 0–30% percent of patients that were new to the practice, only 22.9% of dentists had 0–30% of their patients with decayed teeth, and the majority (73.0%) had 0–30% of patients with a denture present, and the highest percentage of dentists (40.7%) had patients who resided in less socially disadvantaged areas.

Associations of services with dentist, practice and patient factors

Table 2 presents service provision by the dentist factors of treatment choice, practice beliefs, preferences for patients and dentist demographic characteristics. Dentists in the Treatment Choice driven by Patients cluster provided restorative services at a higher rate. Dentists with higher ratings on the Believe in Information Giving scale had lower rates of diagnostic services. Extraction rates were lower for dentists with higher ratings on the Believe in Preventive Orientation scale but were higher for dentists who had higher ratings on the Patient Enabling Characteristics Preference sub-scale.

Table 3 presents service provision by the practice factors of type, location, size and volume of practice. Solo practice was associated with lower diagnostic rates, but higher rates of prosthodontic services. Capital city location was associated with higher rates of preventive services, but lower rates of extraction and prosthodontic services. Working with fewer other dentists was associated with a lower extraction rate, and working with fewer full-time equivalent non-dentist staff was associated with lower restorative rates. Shorter waiting time for an appointment was associated with a higher rate of preventive services. Treating fewer patient visits per year was associated with higher rates of diagnostic and extraction services.

Table 4 presents service provision by the patient factors of visit details, patient demographics, oral health status and socio-economic status of residential location. Emergency visits were associated with lower preventive rates, but higher extraction rates. Insurance status was associated with higher preventive and lower extraction rates. New patients were associated with higher extraction rates. A higher percentage of patients in the age group

Table 2. Service provision per visit by dentist factors

Dentist factors	Diagnostic	Preventive	Restorative	Extraction	Prosthodontic
1. Treatment choice			*		
Treatment choice driven by					
Patient cluster	0.65 (0.04)	0.36 (0.05)	0.79 (0.07)	0.09 (0.02)	0.12 (0.04)
Constraints cluster	0.79 (0.08)	0.36 (0.04)	0.52 (0.05)	0.09 (0.02)	0.09 (0.03)
Patients' Oral Health cluster	0.70 (0.03)	0.37 (0.03)	0.63 (0.04)	0.08 (0.01)	0.08 (0.02)
2. Practice beliefs					
Believe in Information Giving	*				
Higher belief rating (scale scores ≤2.0)	0.68 (0.03)	0.37 (0.02)	0.65 (0.03)	0.09 (0.01)	0.09 (0.02)
Lower belief rating (scale scores >2.0)	0.88 (0.10)	0.33 (0.04)	0.62 (0.06)	0.08 (0.02)	0.10 (0.04)
Believe in Preventive Orientation				*	
Higher belief rating (scale scores ≤2.0)	0.71 (0.04)	0.37 (0.03)	0.66 (0.04)	0.06 (0.01)	0.08 (0.02)
Lower belief rating (scale scores >2.0)	0.71 (0.04)	0.36 (0.03)	0.63 (0.04)	0.10 (0.01)	0.09 (0.02)
Believe in Giving Patient Influence					
Higher belief rating (scale scores ≤2.0)	0.70 (0.03)	0.37 (0.02)	0.65 (0.03)	0.09 (0.01)	0.09 (0.01)
Lower belief rating (scale scores >2.0)	0.73 (0.07)	0.34 (0.05)	0.60 (0.06)	0.06 (0.02)	0.11 (0.05)
3. Dentist rating for patients					
Treatment Adherence Preference					
Higher preference (sub-scale scores ≤2.0)	0.72 (0.03)	0.37 (0.02)	0.65 (0.03)	0.08 (0.01)	0.09 (0.02)
Lower preference (sub-scale scores >2.0)	0.63 (0.06)	0.34 (0.05)	0.60 (0.06)	0.11 (0.03)	0.07 (0.03)
Social Interactiveness Preference					
Higher preference (sub-scale scores ≤2.0)	0.73 (0.05)	0.34 (0.03)	0.67 (0.04)	0.10 (0.02)	0.11 (0.03)
Lower preference (sub-scale scores >2.0)	0.69 (0.03)	0.38 (0.03)	0.62 (0.04)	0.07 (0.01)	0.07 (0.02)
Patient Adaptability Preference					
Higher preference (sub-scale scores ≤2.0)	0.73 (0.03)	0.37 (0.02)	0.65 (0.03)	0.08 (0.01)	0.09 (0.02)
Lower preference (sub-scale scores >2.0)	0.62 (0.05)	0.36 (0.04)	0.62 (0.05)	0.08 (0.02)	0.09 (0.03)
Patient Enabling Characteristics Preference				*	
Higher preference (sub-scale scores ≤2.0)	0.72 (0.06)	0.36 (0.04)	0.66 (0.06)	0.11 (0.02)	0.10 (0.04)
Lower preference (sub-scale scores >2.0)	0.70 (0.03)	0.36 (0.02)	0.63 (0.03)	0.07 (0.01)	0.09 (0.01)
4. Dentist demographics characteristics					
Sex of dentist					
Male	0.71 (0.03)	0.35 (0.02)	0.62 (0.03)	0.08 (0.01)	0.09 (0.02)
Female	0.70 (0.06)	0.41 (0.05)	0.72 (0.08)	0.09 (0.03)	0.08 (0.03)
Age of dentist					
20–29 years	0.81 (0.08)	0.42 (0.05)	0.64 (0.06)	0.10 (0.03)	0.07 (0.03)
30–39 years	0.64 (0.05)	0.37 (0.04)	0.71 (0.06)	0.07 (0.01)	0.07 (0.02)
40–49 years	0.72 (0.06)	0.35 (0.04)	0.64 (0.05)	0.08 (0.02)	0.14 (0.04)
50+ years	0.71 (0.05)	0.34 (0.05)	0.57 (0.05)	0.08 (0.02)	0.08 (0.02)

All values are presented as mean (SE).
*$P < 0.05$.

25–44 years were associated with a lower rate of prosthodontic services. Decayed teeth were associated with lower preventive and prosthodontic rates, but higher restorative and extraction rates. Patients with dentures were associated with higher prosthodontic rates. Patients from disadvantaged areas were associated with lower preventive rates, but higher extraction and prosthodontic rates.

Multivariate models of services by dentist, practice and patient factors

Table 5 presents rate ratios (RR) from multivariate models of service rates by dentist, practice and patient factors. Among the dentist factors: the Treatment Choice driven by Patients cluster was associated with higher restorative rates (RR = 1.27). A higher rating on the Believe in Information Giving scale was associated with lower diagnostic rates (RR = 0.78). A higher rating on the Treatment Adherence Preference sub-scale was associated with a lower rate of extraction services (RR = 0.61). Dentists with higher ratings on the Patient Social Interactiveness Preference sub-scale had higher extraction rates (RR = 1.57) while dentists with higher ratings on the Patient Adaptability Preference sub-scale had lower prosthodontic rates (RR = 0.38). Male dentists had a lower rate of preventive services (RR = 0.74). Dentists aged 20–29 years had higher preventive rates (RR = 1.48) than those aged 65+ years, while dentists aged 30–39 years had higher restorative rates (RR = 1.25) than those aged 65+ years old.

Among practice factors: solo practice was associated with higher rates of preventive (RR = 1.28)

Table 3. Service provision per visit by practice factors

Practice factors[a]	Diagnostic	Preventive	Restorative	Extraction	Prosthodontic
1. Type of practice	**	*			
Practice type					
Solo practice	0.64 (0.04)	0.40 (0.03)	0.61 (0.05)	0.07 (0.01)	0.11 (0.03)
Non-solo practice	0.76 (0.03)	0.34 (0.03)	0.66 (0.03)	0.09 (0.01)	0.07 (0.02)
2. Location of practice					
Geographic location	**	*	**		
Capital city	0.73 (0.03)	0.41 (0.02)	0.65 (0.03)	0.08 (0.01)	0.07 (0.01)
Non-capital city	0.65 (0.04)	0.23 (0.02)	0.63 (0.04)	0.11 (0.02)	0.17 (0.04)
3. Size of practice					
Number of other dentists	**				
Work with fewer dentists (≤median: 1.0)	0.68 (0.03)	0.38 (0.02)	0.62 (0.03)	0.07 (0.01)	0.09 (0.02)
Work with more dentists (>median:1.0)	0.76 (0.05)	0.32 (0.04)	0.68 (0.05)	0.12 (0.02)	0.10 (0.03)
Number of non-dentist staff	*				
Fewer non-dentist staff (≤median: 2.11)	0.69 (0.04)	0.36 (0.03)	0.59 (0.03)	0.09 (0.01)	0.09 (0.02)
More non-dentist staff (>median: 2.11)	0.73 (0.04)	0.36 (0.03)	0.70 (0.05)	0.08 (0.01)	0.09 (0.02)
4. Volume of practice					
Waiting time for an appointment	*				
Shorter waiting time (≤median: 4.0 days)	0.74 (0.04)	0.41 (0.03)	0.63 (0.04)	0.09 (0.01)	0.09 (0.02)
Longer waiting time (>median: 4.0 days)	0.68 (0.04)	0.32 (0.03)	0.66 (0.04)	0.07 (0.01)	0.09 (0.02)
Patient visits treated per year	**	*			
Fewer patients per year (≤median: 2664)	0.80 (0.04)	0.40 (0.03)	0.60 (0.04)	0.10 (0.02)	0.10 (0.02)
More patients per year (>median: 2664)	0.61 (0.03)	0.33 (0.03)	0.69 (0.04)	0.06 (0.01)	0.08 (0.02)

All values are presented as mean (SE).
[a]Main private practice.
*$P < 0.05$; **$P < 0.01$.

and prosthodontic services (RR = 2.07). Capital city location was associated with higher preventive (RR = 1.34) but lower prosthodontic rates (RR = 0.42). Working with fewer other dentists was associated with lower rates of diagnostic (RR = 0.82) and extraction services (RR = 0.55). Providing lower numbers of patient visits per year was associated with higher rates of diagnostic (RR = 1.33) and extraction (RR = 1.62) services but a lower rate of restorative services (RR = 0.84).

Among patient factors: emergency visits were associated with lower preventive (RR = 0.76) and higher extraction rates (RR = 1.45). Insurance status was associated with a lower extraction rate (RR = 0.60). New patients were associated with a higher rate of diagnostic services (RR = 1.17). Decayed teeth were associated with higher restorative (RR = 1.31) but lower prosthodontic rates (RR = 0.46). Patients with dentures were associated with higher prosthodontic rates (RR = 2.14). Residing in a lower socio-economic status location was associated with a lower preventive rate (RR = 0.66), but higher rates of extraction (RR = 2.22) and prosthodontic services (RR = 1.82).

Pseudo R^2 values were highest for the extraction and prosthodontic models. Values of pseudo R^2 ranged from 0.043 for the restorative model to 0.138 for the extraction model.

Discussion

Representativeness of findings

The findings are restricted to adult patients receiving treatment in the private sector. This avoids problems of overlap with care provided through the School Dental Service, which is a major source of dental care among children in Australia (e.g. 61.6% of 5–11-year-old who visited in the last year made their last visit to a school dental clinic) (18). It is likely that the results can be generalized to represent the Australian context as they were from a national survey based on a random sample from a comprehensive sampling frame (i.e. all the state/territory dental registers) which achieved an acceptable response rate (35), and were restricted to private general practitioners who comprise the majority of dentists in Australia. The use of service data from a self-selected typical day could potentially introduce bias if dentists selected a day to show their practice in the best light. This bias should be minimized in this study through the confidentiality provisions of the survey process. Furthermore, a report found there was no significant difference in service rates in all 10 main areas of service between data collected over a 10-day sampling period compared with estimates based on one typical day nominated

Table 4. Service provision per visit by patient factors

Patient factors[a]	Diagnostic	Preventive	Restorative	Extraction	Prosthodontic
1. Visit details	**	**			
Emergency visits					
Higher % emergencies (>median: 23%)	0.72 (0.04)	0.30 (0.03)	0.61 (0.03)	0.11 (0.02)	0.07 (0.01)
Lower % emergencies (≤median: 23%)	0.70 (0.04)	0.43 (0.03)	0.67 (0.05)	0.06 (0.01)	0.11 (0.02)
Insured patients	**	**			
Higher % insured (>median: 50%)	0.69 (0.03)	0.43 (0.03)	0.65 (0.05)	0.06 (0.01)	0.11 (0.03)
Lower % insured (≤median: 50%)	0.73 (0.04)	0.31 (0.02)	0.63 (0.03)	0.11 (0.01)	0.07 (0.02)
New patients	*				
Higher % new patients (>median: 9%)	0.74 (0.04)	0.34 (0.03)	0.61 (0.03)	0.11 (0.01)	0.08 (0.02)
Lower % new patients (≤median: 9%)	0.67 (0.04)	0.39 (0.03)	0.68 (0.05)	0.06 (0.01)	0.10 (0.02)
2. Patient demographics					
Patients aged 25–44 years	*				
Higher % 25–44 yrs (>median: 42%)	0.72 (0.04)	0.36 (0.03)	0.68 (0.04)	0.09 (0.01)	0.07 (0.02)
Lower % 25–44 yrs (≤median: 42%)	0.70 (0.04)	0.36 (0.03)	0.60 (0.04)	0.07 (0.01)	0.12 (0.02)
3. Patient oral health status					
Patients with decayed teeth	**	**	*	**	
Higher % with decay (>median: 56%)	0.68 (0.04)	0.30 (0.03)	0.72 (0.04)	0.10 (0.01)	0.05 (0.01)
Lower % with decay (≤median: 56%)	0.74 (0.04)	0.43 (0.03)	0.56 (0.03)	0.06 (0.01)	0.13 (0.03)
Patients with dentures	**				
Higher % with dentures (>median: 20%)	0.66 (0.04)	0.35 (0.03)	0.60 (0.04)	0.08 (0.01)	0.15 (0.03)
Lower % with dentures (≤median: 20%)	0.74 (0.04)	0.38 (0.03)	0.67 (0.04)	0.08 (0.01)	0.04 (0.01)
4. Socio-economic status					
Disadvantaged patients (SES index)	**	**	*		
Lower SES (index ≤median: 1029)[b]	0.68 (0.04)	0.27 (0.02)	0.60 (0.03)	0.12 (0.02)	0.12 (0.02)
Higher SES (index >median: 1029)[c]	0.74 (0.04)	0.45 (0.03)	0.68 (0.05)	0.04 (0.01)	0.06 (0.02)

All values are presented as mean (SE).
[a]Dentate patients aged 18 years or more from service log.
[b]Aggregated patient SEIFA index scores of relative socio-economic disadvantage ≤ median (from more disadvantaged postcode areas).
[c]Aggregated patient SEIFA index scores of relative socio-economic disadvantage > median (from less disadvantaged postcode areas).
*$P < 0.05$; **$P < 0.01$.

from the 10-day sampling period by the responding dentists (36).

Associations with service provision

All five models of service areas included significant effects for dentist, practice and patient factors. Rate ratios in the range 0.0–0.3 or ≥2.6 indicate strong effects, 0.4–0.5 or 1.7–2.5 moderate effects, and 0.6–0.8 or 1.2–1.6 weak effects, while those in the region of 0.9–1.1 are considered as indicating no effect (30). The majority of effects would be considered as weak except for prosthodontic services where mainly moderate effects occurred, and for the effect of socio-economic status of the residential location of patients with extraction rates. While the pseudo R^2 values might be considered low, suggesting considerable variation was not explained, they need to be considered in context – variance in service rates explained by models has generally been small (5), and models of survey data suffer from a lack of sensitivity associated with the use of general measures of persons and environment (37). In addition, some caution needs to be adopted in the use of pseudo R^2 values as they reflect values fitted under two models rather than comparing observed values with values fitted under one model (38).

It may be that additional factors not included in the models, such as dentists' knowledge of risk factors for caries and diagnostic criteria can add further explanatory value. There is also some evidence that dentists adopt styles of practice, but while the styles themselves are relatively stable over time individual dentists may move from one style to another (36). The unit of analysis is another consideration – further models based on episodes or courses of care would be useful to compare against results obtained using patient visits. However, respondent burden is an issue that makes collection of such data problematic. Further understanding of the association of services with location may need to address the interaction of a range of issues such as fluoridation status, level of supply of dentists, and oral health status of the population in

Table 5. Rate ratios (RR) and 95% confidence intervals (95% CI) from multivariate negative binomial regression models of services per visit by dentist, practice and patient factors

	Diagnostic	Preventive	Restorative	Extraction	Prosthodontic
Dentist factors					
1. Treatment choice driven by					
Patient cluster[1]	0.93 (0.78–1.10)	0.98 (0.77–1.25)	*1.27 (1.05–1.53)	1.00 (0.64–1.56)	1.60 (0.85–3.00)
Constraints cluster[1]	1.08 (0.91–1.27)	0.96 (0.75–1.22)	0.88 (0.71–1.06)	1.29 (0.76–1.83)	1.07 (0.58–1.98)
2. Practice beliefs					
Believe in Information Giving[2]	*0.78 (0.64–0.94)	1.08 (0.80–1.44)	0.98 (0.78–1.23)	0.90 (0.54–1.50)	1.12 (0.51–2.44)
Believe in Preventive Orientation[2]	1.00 (0.87–1.15)	0.90 (0.74–1.10)	1.14 (0.98–1.33)	0.73 (0.50–1.06)	1.59 (0.95–2.66)
Believe in Giving Patient Influence[2]	0.96 (0.79–1.15)	1.19 (0.90–1.56)	1.14 (0.92–1.40)	1.04 (0.63–1.74)	0.74 (0.36–1.51)
3. Dentist preference rating for patients					
Treatment Adherence[3]	1.10 (0.88–1.37)	1.27 (0.93–1.75)	0.96 (0.75–1.23)	*0.61 (0.35–1.05)	2.16 (0.93–5.03)
Social Interactiveness[3]	1.03 (0.88–1.22)	0.84 (0.67–1.06)	1.09 (0.91–1.31)	*1.57 (1.02–2.43)	1.50 (0.82–2.78)
Patient Adaptability[3]	1.11 (0.90–1.36)	0.97 (0.72–1.30)	0.92 (0.73–1.16)	0.98 (0.58–1.67)	*0.38 (0.17–0.87)
Patient Enabling Characteristics[3]	0.90 (0.75–1.07)	1.08 (0.83–1.39)	1.08 (0.88–1.32)	1.27 (0.83–1.95)	0.77 (0.39–1.51)
4. Dentist demographic characteristics					
Male dentist[4]	1.08 (0.89–1.30)	*0.74 (0.56–0.96)	0.85 (0.69–1.04)	0.98 (0.61–1.58)	0.75 (0.38–1.47)
Dentist age: 20–29 years[5]	0.95 (0.76–1.18)	*1.48 (1.08–2.04)	1.08 (0.83–1.40)	0.78 (0.43–1.41)	0.76 (0.32–1.78)
Dentist age: 30–39 years[5]	0.84 (0.70–1.01)	1.11 (0.86–1.46)	*1.25 (1.01–1.54)	0.76 (0.46–1.26)	0.78 (0.39–1.54)
Dentist age: 40–49 years[5]	1.00 (0.84–1.20)	1.11 (0.85–1.44)	1.13 (0.91–1.39)	0.87 (0.53–1.41)	1.36 (0.72–2.57)
Practice factors[a]					
1. Type of practice					
Solo practice[6]	0.90 (0.77–1.05)	*1.28 (1.03–1.59)	0.88 (0.74–1.05)	0.98 (0.63–1.52)	*2.07 (1.15–3.71)
2. Location of practice					
Capital city[7]	1.05 (0.87–1.26)	*1.34 (1.01–1.77)	0.95 (0.77–1.17)	0.90 (0.58–1.41)	**0.42 (0.22–0.79)
3. Size of practice					
Number of dentists (≤median: 1.0)[8]	*0.82 (0.69–0.96)	1.07 (0.84–1.36)	1.12 (0.93–1.34)	**0.55 (0.36–0.84)	0.79 (0.42–1.47)
No. non-dentist staff (≤median: 2.11)[9]	0.93 (0.81–1.07)	0.99 (0.82–1.21)	0.86 (0.74–1.01)	0.99 (0.69–1.44)	0.97 (0.56–1.65)
4. Volume of patients					
Waiting time (≤median: 4.0 days)[10]	0.98 (0.85–1.13)	1.15 (0.94–1.40)	1.03 (0.87–1.21)	0.95 (0.65–1.40)	1.47 (0.84–2.56)
Patients per year (≤median: 2664)[11]	**1.33 (1.15–1.54)	0.99 (0.80–1.22)	*0.84 (0.71–0.99)	*1.62 (1.09–2.40)	1.27 (0.72–2.27)
Patient factors[b]					
1. Visit details					
Emergencies (>median: 23%)[12]	1.09 (0.96–1.25)	**0.76 (0.62–0.92)	0.89 (0.77–1.03)	*1.45 (1.01–2.08)	0.93 (0.57–1.51)
Insured patients (>median: 50%)[13]	0.99 (0.86–1.13)	1.19 (0.97–1.45)	1.03 (0.88–1.20)	**0.60 (0.41–0.88)	1.61 (0.94–2.77)
New patients (>median: 9%)[14]	*1.17 (1.01–1.35)	0.93 (0.76–1.14)	0.90 (0.77–1.06)	1.38 (0.93–2.04)	0.82 (0.48–1.40)
2. Patient demographics					
Patients 25–44 yrs (>median: 42%)[15]	0.97 (0.84–1.12)	0.98 (0.79–1.20)	1.09 (0.92–1.29)	1.13 (0.76–1.68)	0.67 (0.39–1.16)
3. Patient oral health status					
Patients with decay (>median: 56%)[16]	0.90 (0.78–1.03)	0.83 (0.68–1.02)	**1.31 (1.12–1.53)	1.13 (0.79–1.63)	**0.46 (0.28–0.77)
Patients with dentures (>median: 20%)[17]	0.90 (0.77–1.04)	0.97 (0.78–1.19)	0.97 (0.82–1.15)	0.93 (0.62–1.40)	**2.14 (1.26–3.65)

Table 5. Continued

	Diagnostic	Preventive	Restorative	Extraction	Prosthodontic
4. Socio-economic status					
Lower SES (index ≤median: 1029)[18]	0.92 (0.79–1.08)	**0.66 (0.53–0.82)	0.90 (0.76–1.06)	**2.22 (1.47–3.36)	*1.82 (1.02–3.25)
P-value for model:	**	**	**	**	**
Pseudo R^2	0.045	0.073	0.043	0.138	0.129

All values are presented as RR (95% CI).
Reference categories: [1]Treatment choice driven by Patients' Oral Health cluster; [2]scale scores > 2.0 (less agreement with practice belief); [3]sub-scale scores > 2.0 (lower preference rating); [4]female dentists; [5]dentists aged 50+ years; [6]non-solo practice; [7]non-capital city; [8]number of dentists >median; [9]number of non-dentist staff > median; [10]waiting time > median; [11]patients per year > median; [12]% emergencies ≤ median; [13]% insured patients ≤ median; [14]% new patients ≤ median; [15]% patients aged 25–44 years ≤ median; [16]% patients with decayed teeth ≤ median; [17]% patients with dentures ≤ median; [18]higher SES-aggregated patient SEIFA index scores of relative socio-economic disadvantage > median (from less disadvantaged postcode areas).
[a]Main private practice; (b) dentate patients aged 18 years or more from service log.
*$P < 0.05$; **$P < 0.01$.

a location that may impact on service rates directly or shape practice norms.

While the effects were small in size at the level of rate per visit, the potential impact on patients could be substantial over a longer period of dental care. The average number of visits per year by those attending for dental care was 2.4 visits in 1994 (18). The rate ratio of 1.48 for 20–29-year-old dentists multiplied by the rate of preventive services of 0.36 per visit gives an excess of 0.17 preventive services per visit. While small at the visit level, when multiplied by 2.4 visits per year gives 0.408 preventive services per year for patients of those dentists which if they remained in continuous care would accrue to 4.08 more preventive services over a 10-year period. Similarly, the rate ratio of 1.28 for restorative care among dentists who rated patient preferences highly in choosing alternative treatments would yield 4.32 extra restorations for a patient in their continuous care over 10 years. These effects partly reflect the relatively high rates of preventive and restorative services, but even for service areas with lower rates such as extractions the rate ratio of 0.61 for dentists with higher preferences for patients that exhibited behaviour relevant to adherence with treatment would yield 0.96 less extractions over a 10-year period, while the rate ratio of 1.57 for dentists with higher preferences for communicative and appreciative patients would yield 1.2 more extractions for their patients over a 10-year period. While these effects assume continuous care over extended periods and attribute average visiting rates to all patients they illustrate that small effects at the visit level could make a large difference over the dental lifespan of a patient.

Dentist factors

Only one treatment choice variable and one practice belief variable was significantly associated with service provision. However, three variables relating to dentist preferences for patients and three dentist demographic characteristics were significantly associated with service rates. The effect of treatment choice has been demonstrated to involve dentists who consider patient factors such as patient preference when choosing treatments providing more multiple-surface ionomers and resins (23). This could indicate that patients who seek out dentists who regard the patient as important when selecting treatment are more interested in alternatives and more favourable toward choosing such materials. The practice belief factors may be underidentified and require more items to measure them with greater reliability (24). However, despite this those dentists who had stronger beliefs on the importance of giving information had a significantly lower diagnostic rate indicating that practice beliefs are associated with service rates.

The association of dentist preferences with service rates indicates that the dentist–patient relationship impacts on the mix of services provided, possibly through a selection process that matches values of dentists and patients. Dentists with preferences for patients who were adherent with treatment had a lower extraction rate and those with preferences for patients who were adherent in general had a lower rate of denture services. The higher extraction rates among dentists with preferences for sociable patients suggests that these dentists may allow the preferences of patients to play a greater role in choosing cheaper treatment options most likely in contrast

to the desire of a dentist to restore and maintain the dentition.

The association of dentist demographic characteristics indicates that some variation in service rates can be attributed to the age and sex of the dentist. Gender differences have been observed for the service patterns of health care providers, however, there appears to be fewer gender-specific associations in dentistry compared with medicine which most likely reflects the lack of gender-specific types of oral health problems in dentistry when compared with medicine where some health issues are seen as masculine and some as feminine providing a source of differentiation (39). Associations of services by sex of dentist have been reported as being small in terms of effect size (40), and the distribution of the 10 main areas of service being similar in rank order between male and female dentists (41). However, the significant negative association for male dentists with preventive services may indicate that preventive orientation is one source of differentiation. Age differences can have a variety of sources spanning aging, period and cohort influences that cannot be disentangled in a cross-sectional analysis. Patterns of dental service provision in Australia, while associated with age of dentist, have generally lacked consistent trends (41). Further observation would be required to ascertain whether the higher preventive rate noted here among younger dentists is maintained as they age and whether future members of this age group will also adopt this pattern of preventive care.

Practice factors

Practice factors such as location of practice (8, 9) have been established as predictors of service rates from previous analyses and other practice factors, while not hypothesized to have specific associations with service rates, were included in order to control for their possible effects. A range of practice factors was associated with service provision spanning the type, location, size and volume of the practice. This confirmed previous observations related to urban location of practice with a service pattern oriented more to prevention and less to prosthodontic care (8, 9). Such patterns of care have been related to the geographical distribution of supply of dentists. The interpretation of the relationship between service patterns and practice factors could be enhanced by improved knowledge of the impact of busyness on under- and over-servicing. While not the focus of this study there was widespread variation in services related to practice factors, indicating that these contribute to differences in service profiles after controlling for dentist and patient factors. However, the assessment of the effect of practice factors is not straightforward and there is a need to consider a range of variables in addition to supply, covering aspects such as need and demand (42), and the structure and function of dental markets (43).

Patient factors

Factors relating to patients, particularly oral health status, are expected to be related to service provision, and a range of patient factors that have been shown to be associated with services in previous analyses (2, 10, 11, 15, 16) were included in the analysis in order to examine their effect. Among the range of patients factors associated with service provision some of the larger effects were observed for the proportion of patients with dentures and prosthodontic services, and the socio-economic status of patients residential location with extractions. Socio-economic status of residential location was also associated with a higher prosthodontic rate and a lower preventive rate. Other patient factors associated with more than one service area included proportions of patients with decayed teeth and the proportion of emergency visits.

Sources of variation in service rates

In response to the widespread variation observed in medical service rates it was noted that it is not enough to document variations, or even demonstrate their impact on health outcomes, but in order to improve the care that is delivered the challenge is to understand the underpinnings of practice patterns (44). Variation in service rates may be acceptable under some circumstances, such as underlying differences in the health status of populations (45). In this study, variation in service rates persisted after controlling for oral health status. Variability between treatments planned for similar conditions may also be acceptable providing there is a rational basis for the choices that have been made (46). The optimal treatment plan should be dictated by what outcome can be achieved and how valuable this is to the patient; therefore patient preferences are an important part of clinical decision-making (47). Other potential sources of influence in this process comprise dentist and practice factors. In this study, a range of dentist and practice factors were associated with

service rates after controlling for patient factors. A framework (44) for understanding provider-based factors influencing the provision of services can include the personal interests and desires of the provider (e.g. desire for income, desire for style of practice, personal characteristics of providers, practice setting), and consideration of patient benefit (e.g. patient's economic well-being, clinical factors, patient demand, patient convenience) and social good (e.g. health system efficiency). The dentist-based factors of treatment choice, practice beliefs, preferences for patients and demographic characteristics were associated with service rates in this study. An episode of dental care is seen as a social process, a key element of which is the exchange relationship between patient and provider, which is structured by the environment and also the characteristics of dentists and patients (48). Further understanding of the impact of dentist-based factors on practice patterns may be achieved by learning more about how these factors originate and develop over time, and interact with patient-based factors.

Summary and conclusions

Overall, service provision was influenced by a large number of small effects from a wide range of factors. While oral health status has an influence on the provision of services it is not the sole determinant. A range of dentist, practice and patient factors also influence the service provision process. The findings of this study indicated dentist factors such as treatment choices, practice beliefs, preferences for patients and demographic characteristics had an influence on service patterns. Such findings indicate that further understanding of the dentist–patient relationship, the development of treatment choices and practice beliefs, and the dynamics of treatment planning and decision-making could be beneficial in improving service outcomes. The persistence of some geographic and area-based gradients in services indicates the operation of socio-economic and geographic barriers on service patterns. However, other factors such as insurance status and visit type were also associated with service patterns and have the potential to be manipulated to achieve better service outcomes. While socio-economic and geographic barriers may require broad policy innovations to address their effects on service provision, there is scope for research into clinical outcomes in general practice to improve the knowledge based upon which treatment decisions are made, and such information could provide the basis for the development of practice parameters and guidelines for care to address potential problems with appropriateness of care which stem from the observed variation in service provision.

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References

1. Wennberg J. Which rate is right? N Engl J Med 1986;314:310–1.
2. Bailit H, Clive J. The development of dental practice profiles. Med Care 1981;19:30–46.
3. Bader JD, Shugars DA. Variation, treatment outcomes, and practice guidelines in dental practice. J Dent Educ 1995;59:61–95.
4. Bader JD. The emergence of appropriateness-of-care issues. J Dent Res 1992;71:502–4.
5. Grembowski D, Milgrom P, Fiset L. Dental decision making and variation in dentist service rates. Soc Sci Med 1991;32:287–94.
6. Bader JD, Shugars DA. Variation in dentists' clinical decisions. J Pub Health Dent 1995;55:181–8.
7. Grembowski D, Milgrom P, Fiset L. Factors influencing variation in dentist service rates. J Pub Health Dent 1990;50:244–50.
8. Brennan DS, Spencer AJ, Szuster FSP. Rates of dental service provision between capital city and non-capital locations in Australian private general practice. Aust J Rural Health 1998;6:12–7.
9. Brennan DS, Spencer AJ, Slade GD. Provision of public dental services in urban, rural and remote locations. Community Dent Health 1996;13:157–62.
10. Spencer AJ, Lewis JM. Service-mix in general dental practice in Australia. Aust Dent J 1989;34:69–74.
11. Brennan DS, Spencer AJ, Szuster FSP. Service provision trends between 1983–84 and 1993–94 in Australian private general practice. Aust Dent J 1998;43:331–6.
12. Manning WG, Bailit HL, Benjamin B, Newhouse JP. The demand for dental care: evidence from a randomized trial in health insurance. J Am Dent Assoc 1985;110:895–902.
13. Bailit H, Newhouse J, Brook R, Duan N, Goldberg G, Hamley J, et al. Does more generous dental insurance coverage improve oral health? J Am Dent Assoc 1985;110:701–7.
14. Mueller CD, Monheit AC. Insurance coverage and the demand for dental care. Results for non-aged whites. J Health Econ 1988;7:59–72.
15. Brennan DS, Spencer AJ, Szuster FSP. Insurance status and provision of dental services in Australian

private general practice. Community Dent Oral Epidemiol 1997;25:423–8.
16. Brennan DS, Spencer AJ. Influence of patient, visit and oral health factors on dental service provision. J Pub Health Dent 2002;62:148–57.
17. Szuster FSP, Spencer AJ. Dental Practitioner Statistics, Australia, 1994. AIHW Dental Statistics and Research Series no. 11. Adelaide, SA, Australia: The University of Adelaide; 1997.
18. Carter K, Stewart J, Davies M, Szuster F, Allister J, Slade G, et al. National Dental Telephone Interview Survey 1994. Adelaide, SA, Australia: AIHW Dental Statistics and Research Unit; 1994.
19. Dillman DA. Mail and Telephone Surveys. The Total Design Method. New York, NY, USA: Wiley and sons; 1978.
20. Rouse RA, Hamilton MA. Dentists evaluate their patients: an empirical investigation of preferences. J Behav Med 1991; 14:637–48.
21. Grembowski D, Milgrom P, Fiset L. Clinical decision making among dental students and general practitioners. J Dent Educ 1989;53:189–92.
22. Grembowski D, Milgrom P, Fiset L. Factors influencing dental decision making. J Pub Health Dent 1988;48:159–67.
23. Brennan DS, Spencer AJ. Factors influencing choice of dental treatment by private general practitioners. Int J Behav Med 2002; 9:94–110.
24. Brennan DS, Spencer AJ. Practice belief scales among private general dental practitioners. Aust Dent J 2001;46:186–93.
25. Brennan DS, Spencer AJ. Dentist Preferences for Patients: Dimensions and Associations with Provider, Practice and Service Characteristics. Int J Behav Med 2005; in press.
26. Australian Dental Association. An Australian Schedule of Dental Services and Glossary. Fifth edition 1996. St Leonards, NSW, Australia: Australian Dental Association; 1996.
27. Australian Bureau of Statistics. Information Paper. 1991 Census. Socio-economic Indexes for Small Areas. Canberra, Australia: ABS; 1993. Catalogue no. 2912.0.
28. Rothman KJ. Modern Epidemiology. Boston, MA, USA: Little, Brown and Company; 1986.
29. Elwood JM. Causal Relationships in Medicine. Oxford, UK: Oxford University Press; 1992.
30. Sahai H, Khurshid A. Statistics in Epidemiology. Methods, Techniques and Applications. Boca Raton, FL, USA: CRC Press; 1996.
31. Glynn RJ, Buring JE. Ways of measuring recurrent events. Br Med J 1996;312:364–6.
32. Diehr P, Grembowski D. A small area simulation approach to determining excess variation in dental procedure rates. Am J Public Health 1990;80:1343–8.
33. StataCorp. Stata Statistical Software: Release 6.0. College Station, TX, USA: Stata Corporation; 1999.
34. Selvin S. Statistical Analysis of Epidemiologic Data. Oxford, UK: OUP; 1996.
35. Mangione TW. Mail Surveys. Improving the Quality. Beverly Hills, CA, USA: Sage; 1995.
36. Brennan DS, Spencer AJ, Szuster FSP. Dentist service rates and distribution of practice styles over time. Community Dent Oral Epidemiol 1996;24:145–51.
37. Mechanic D. Correlates of physician utilization: why do some major multivariate studies of physician utilisation find trivial psychosocial and organizational effects? J Health Soc Behav 1979;20:387–96.
38. Hosmer DW, Lemeshow S. Applied Logistic Regression. New York, NY, USA: Wiley and sons; 1989.
39. Bensing JM, Van den Brink-Muinen A, De Bakker DH. Gender differences in practice style: a Dutch study of general practitioners. Med Care 1993;31: 219–29.
40. Kent DL, Carter KD, Spencer AJ. Service-mix provision by male and female dentists in Australia. J Dent Res 1998;77:1136 (abstract).
41. Brennan DS. Dental Service Provision in Private General Practice: Patterns and Trends. Adelaide, SA, Australia: Master of Public Health thesis, Department of Public Health, The University of Adelaide; 1997.
42. Furino A, Douglass CW. Balancing dental service requirements and supplies: the economic evidence. J Am Dent Assoc 1990;121:685–92.
43. Grembowski D, Conrad D, Weaver M, Milgrom P. The structure and function of dental-care markets. Med Care 1988;26:132–47.
44. Eisenberg JM. Physician utilization. The state of research about physicians' practice patterns. Med Care 1985;23:461–83.
45. Smits HL. Medical practice variations revisited. Health Affairs 1986;Fall:91–6.
46. Kay E, Nuttall N. Clinical decision making – an art or a science? Part III: To treat or not to treat? Br Dent J 1995;178:153–5.
47. Kay E, Nuttall N. Clinical decision making – an art or a science? Part V: Patient preferences and their influence on decision making. Br Dent J 1995;178:229–33.
48. Grembowski D, Andersen RM, Chen M. A public health model of the dental care process. Med Care Rev 1989;46:439–96.