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Dental service provision by oral health therapists, dental hygienists and dental therapists in Australia: implications for workforce modelling

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Objective: Dental service provision rates are necessary for workforce planning. This study estimates patient and service rates for oral health therapists (OHTs), dental hygienists (DHs) and dental therapists (DTs). To identify important variables for workforce modelling, variations in rates by practice characteristics were assessed. ***Design***: A cross-sectional self-complete mailed questionnaire collected demographic and employment characteristics, and clinical activity on a self-selected typical day of practice. ***Setting***: Private and public dental practices in Australia. ***Participants***: Members of the two professional associations representing DHs, DTs and OHTs. ***Methods:*** For each practitioner type, means and adjusted rate ratios of patients per hour, services per visit and preventive services per visit were estimated. Comparisons by practice characteristics were assessed by negative binomial regression models. ***Results:*** Response rate was 60.6% (n=1,083), 90.9% were employed of which 86.3% were working in clinical practice and completed the service log. Mean services per patient visit provided by OHTs, DHs and DTs were 3.7, 3.5 and 3.3 and mean preventive services per patient were 2.1, 2.1 and 1.8 respectively. For all three groups, adjusting for explanatory variables, the rate of preventive services per patient varied significantly by practice type (general or specialist) and by the proportion of child patients treated. ***Conclusion:*** Services rates varied by age distribution of patients and type of practice. If these factors were anticipated to vary over-time, then workforce planning models should consider accounting for the potential impact on capacity to supply services by these dental workforce groups.

Key words*: dental services, dental service provision rates, dental hygienists, dental therapists, oral health therapists, practice activity, workforce planning, Australia*

Introduction

Oral health therapists (OHTs), dental hygienists (DHs) and dental therapists (DTs) comprise approximately one-fifth of Australia's registered oral health workforce, of which the majority are dentists (75.5%); the remaining 6% consists of dental prosthetists (AIHW, 2014). Compared to their more established counterparts (DHs and DTs), OHTs are an emerging oral health workforce in Australia. Growth in the OHT workforce is expected to contribute to future changes in the size and composition of the total oral health workforce in Australia.

Scope of practice for these practitioners is defined by their education and qualifications. While practitioners may undertake further education to extend their specific scope, broadly the scope of DTs and DHs includes preventive, diagnostic, non-surgical periodontal services and some orthodontic services. Additionally DTs can provide restorative, pulpotomy and extraction services (some patient age restrictions may apply depending on qualifications and clinical setting). OHTs are educated to provide the scope of both DHs and DTs.

While OHTs, DHs and DTs differ in their scopes of practice, recent research has shown that overall their service provision is dominated by preventive and diagnostic services; more than 50% of the services provided were preventive-oriented and approximately 25% were diagnostic (Teusner *et al*., 2015).

Dental workforce supply modelling aimed at maximising the productivity of the workforce is a perennial area of interest and research (HWA, 2014; Teusner *et al.* 2008). More recently there has been increased interest in health workforce skill-mix (Duckett, 2005) and associated modelling assessing the impact on total capacity to supply services under alternate workforce composition and "task-shifting" scenarios. In oral health research there is an emerging interest in skill-mix modelling which has coincided with the emergence of OHTs (Gallagher *et al*., 2010, 2013). Some models have attempted to identify the optimal skill-mix of oral health practitioners in order to meet the needs of specific sub-populations. However, implementing changes to workforce composition and/or scope of practice must also consider feasibility, practicality and desirability by policy makers and consumers. (Gallagher *et al*., 2010, 2013)

These types of modelling often require current estimates of service provision. While the rates of service provision for Australian dentists are available and reliable (Brennan *et al*., 2015), estimates for DHs, DTs and OHTs are limited and possibly outdated. Australian research, which assessed the impact of compositional changes within the dental workforce on supply of dental visits, relied on the substitution of dentist estimates to calculate DT and DH supply (Teusner *et al*., 2008).

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Other research relied on public sector data to model supply of largely private sector workforce outputs (HWA, 2014). Further, lack of service provision data for these three groups has been recognised as a key impediment to conducting more sophisticated work-skill mix modelling (HWA, 2014).

The appropriateness of these proxy estimates has not been assessed but it is suspected that there are substantial differences between OHTs, DHs and DTs. While clinical practice of OHTs, DHs and DTs is dominated by preventive and diagnostic services, there are substantial variations between these groups in terms of other service types (Teusner *et al*., 2015). While some of these differences relate to historical regulatory practice restrictions and education, differences may also be explained by variations in patterns of employment across practice types and sectors. Practice activity may be influenced by types of patients treated and variations in models of care across practice types and sectors. Hence workforce models may be improved by incorporating separate estimates of service provision for each practitioner type and for different practice settings.

This study aimed to estimate service provision rates for OHTs, DHs and DTs. In order to identify variables to incorporate into workforce models, the associations between rates and practitioner and practice characteristics were also assessed.

Methods

Data collection

A self-report questionnaire was developed through consultation with practitioners and academics working in OHT education programs. Data items collected were based on previous research on dentists practice activity and labour force studies of dental practitioners. A pilot study was conducted (n=10) and questionnaires edited according to feedback provided by participants. All members of the Dental Hygienists' Association of Australia (DHAA) and Australian Dental and Oral Health Therapists Association (ADOHTA) were mailed a questionnaire (with up to four reminder mailings) between March and June 2013.

The questionnaire collected participants' demographics, employment status and all current registration types (AHPRA, 2015). Those reporting multiple registration types (i.e. registered as both a DH and a DT) were categorised into one of the three practitioner groups by applying the criteria used in Australian Institute of Health and Welfare (AIHW) oral health labour force reports (AIHW, 2014). Criteria are based on the practitioner's area of employment at their main practice location, state of residence and consider other registration types held by the practitioner. AIHW criteria were applied as this allowed benchmarking of the sample and the use of national workforce estimates (published by AIHW) for weighting of data.

Participants were asked to report the practice characteristics (e.g. type, sector, size) and clinical activity at the location where they usually worked the most hours. Practitioners could keep a tally of their clinical activity during one self-selected day or, alternatively, refer to their records and report on a day recently worked. The clinical activity log recorded direct patient care hours, total number of patients treated and services provided. Services provided and age of patients treated were summarily collected (e.g. total number of scale and cleans provided, total number of patients aged 0–11 years).

Ethics approval was gained from the University of Adelaide Human Research Ethics Committee (HRECH-288-2011).

Variables

The service provision outcome variables were number of patients per direct patient care hour (patient rate), number of total services per patient visit (service rate) and number of preventive services per patient visit (preventive rate). Reporting of preventive services was considered to be important as these services are common to the practice scope of all three practitioners and are of public health importance. Preventive services were items classified by the ADA schedule as preventive, prophylactic and bleaching services (ADA, 2013).

The explanatory variables included practitioner age group (years) and practice characteristics: sector (public or private), practice type (specialist or general practice), length of service at the respective practice, team size (number of clinical practitioners employed) and practice postcode. Years of service was dichotomised as less than 2 years and 2 years or more while team size was categorised as 1–2 practitioners, 3–7 practitioners, and 8 or more practitioners. Practice postcodes were categorised by Australian Statistical Geography Standard Remoteness areas 2011 (ABS, 2013). Due to small numbers, those classified as working in outer regional, remote or very remote areas were grouped as outer regional/remote. The proportion of child patients was calculated by totalling the number of patients in the two youngest age groups (0–11 and 12–17) divided by total number of patients treated.

Analytical approach

Data were weighted to reflect the practitioner type, age and state distribution of registered practitioners (AIHW, 2014). The analysis excluded practitioners who were not working in clinical practice or who did not provide a complete activity log. To assess the potential of bias associated with non-response to the activity log, characteristics of practitioners included in analysis were compared with those who were excluded (differences were assessed by chi-square statistic, $p<0.05$ to be considered significant).

For each practitioner group, the sample of complete cases was described by reporting the distribution by age group and practice characteristics. Service provision was described by calculating means for each service outcome variable.

General linear models have been widely applied in modelling rates of health services received (Gagnon *et al*., 2008). After comparing key diagnostics of models, using various distributions for count data including Akaike Information Criterion and deviance, a negative binomial was determined to be the most appropriate distribution. To assess differences in mean rates by characteristics, the number of services (or number of patients treated) was entered as the dependent variable and, in separate models each characteristic was entered as an independent variable.

The natural log of the total number of patients treated (or direct patient hours) was entered as an offset variable to convert the dependent count variable to a rate. Associations between service provision rates and practice characteristics, adjusting for all explanatory variables, were also assessed in negative binomial models estimating adjusted rate ratios. Correlations between all the explanatory variables were assessed prior to inclusion in the multiple variable models; highly correlated variables were excluded to avoid co-linearity issues. Alternate models, including the excluded variables, were also constructed. Statistical significance was based on confidence intervals not including one. Analysis was performed using SAS 9.3 (Research Triangle, Research Triangle Park, USA).

As practitioners reported on a self-selected day, practitioners may have been inclined to report on a 'busy' day. Potential for bias was assessed by conducting a retest on a subsample of employed OHTs (n=80). The retest questionnaire collected one full working week of clinical activity. Service rates per patient visit were calculated, and the practitioner's one week log and one day log were compared. Differences in rate ratios (estimated by negative binomial regression) were assessed by 95% confidence intervals.

Results

The questionnaire was mailed to 1,861 registered members of ADOHTA and DHAA. The response rate was 60.6% (n=1,086) after accounting for return to sender (n=37) and other exclusions (n=35) (e.g. student members, honorary members). Overall, 90.9% (n=984) were employed, 4.8% (n=52) were on leave for 3 months or longer, and the remainder were overseas, not working or working in another industry (4.4%, n=48). Of the employed practitioners, only 4.0 % were male, OHTs had the highest percentage of male practitioners (6.4%), followed by DHs (3.3%) and DTs (2.5%).

Of those employed, 86.3% (n=850) were included in the practice activity analysis. A small percentage (2.2%, n=21) were not working in clinical practice (e.g. employed in oral health promotion, teaching) and 11.5% (n=113) were excluded from analysis due to missing data. Key demographic and employment characteristics of practitioners included and excluded from analysis were compared (n=850 included and n=113 excluded due to non-response). There were no significant differences between the two groups in terms of their characteristics. However, log response did vary significantly by registration group. Among the three groups, OHTs had the highest proportion completing the log and DTs the lowest. An additional 4.6% (n=46) were excluded from the final analysis due to missing data for one or more of the explanatory variables.

Sector and proportion of child patients were significantly correlated. Those working in the public sector had a moderate to high correlation of having treated more than 80% child patients (OHTs: Spearman's rho=0.69, DHs: Spearman's rho=0.43, DTs: Spearman's rho=0.74). Consequently, models with and without sector of practice were assessed. Models excluding sector are presented in the tables and a series of additional models are discussed in the 'Alternate models' section.

Mean rates and adjusted rate ratios for OHTs are reported in Table 1. Two-thirds of OHTs worked in the private sector and the majority treated more than 80% child patients in their typical day. Mean patient rate varied significantly by practice type and proportion of child patients. After adjusting for other explanatory variables, patient rates were 18% higher for 40 to 49 year old OHTs, 54% lower for OHTs in general practice and 13% lower for those in mid-sized teams (3–7 practitioners) than those in the respective reference groups. There were no variations in mean service rates or corresponding adjusted rate ratios by characteristics. Mean preventive rates varied significantly by sector, practice type and proportion of child patients. The adjusted preventive rate was 59% higher for OHTs in general practice and 18% lower for OHTs who treated 80% or more child patients, than their respective reference groups (Table 1).

Nearly all DHs worked in the private sector and less than one in ten treated more than 80% child patients (Table 2). Mean patient rate varied by practice type, team size, proportion of child patients and region. With the exception of region, these associations persisted after adjusting for other explanatory variables. DHs in general practice had a 55% lower patient rate than those in specialist practice, smaller teams had 12% lower rates than larger teams (8 or more practitioners) and DHs treating 80% or more children had 48% higher rates of patients per hour. Mean service and preventive rates varied by practice type and by proportion child patients. Mean service rate also varied by region. After adjusting for other explanatory variables, DHs in general practice had 60% higher service and over 200% higher preventive rates, and DHs treating 80% or more children had 24% lower service rates than their respective counterparts (Table 2).

Among the DT group, nearly two-thirds worked in the public sector, nearly three-quarters treated more than 80% child patients, and only a small percentage worked in specialist practice (Table 3). Mean patient rate significantly varied by age group, practice type, team size and proportion of child patients. Except for team size, all associations persisted after adjusting for other variables. Older practitioners (>29 years) had between 31% and 26% lower patient rates than younger practitioners (<30 years), DTs in general practice had a 50% lower rate, and DTs treating 80% or more children had 44% higher rates than their respective counterparts. In both unadjusted and adjusted analyses, service rates varied by practice type and region. DTs in general practice had a 44% higher rate and DTs in a major city area had 16% lower rate than their respective counterparts. Mean preventive rates varied by practice type and proportion child patients. Both of these associations remained significant in the adjusted analysis, as was region of practice. Compared to DTs in specialist practice, DTs in general practice had 115% higher preventive rate, DTs treating 80% or more children had 24% lower rates than those treating less than 80% children, and those in a major city area had 24% lower rate than those in outer regional/remote areas (Table 3).

Table 1. Oral health therapists: patient visits per hour and services per patient visit by practitioner demographics and practice characteristics

Characteristics		*Unadjusted associations*						*Adjusted associations*					
		Patients per hour		*Total services per patient*		*Preventive services per patient*		*Patients per hour*		*Total services per patient*		*Preventive services per patient*	
	Distributions	*Mean*[a]	*(SE)*	*Mean*[a]	*(SE)*	*Means*[a]	*(SE)*	*RR* [b]	*95%CI*	*RR* [b]	*95%CI*	*RR* [b]	*95%CI*
Age group (years)	n=245												
<30	54.7%	1.5	(0.1)	3.7	(0.1)	2.2	(0.1)	ref		ref		ref	
30–39	24.9%	1.6	(0.1)	3.7	(0.1)	2.3	(0.1)	1.10	(0.98,1.23)	0.97	(0.88,1.08)	1.01	(0.87,1.17)
40–49	13.5%	1.7	(0.2)	3.5	(0.2)	2.0	(0.1)	1.18	(1.03,1.35)	0.95	(0.83,1.08)	0.93	(0.77,1.12)
50+	6.9%	1.6	(0.1)	3.5	(0.2)	1.7	(0.2)	1.13	(0.93,1.37)	0.96	(0.81,1.15)	0.85	(0.66,1.10)
Sector of practice						*							
Private	66.9%	1.5	(0.1)	3.7	(0.1)	2.3	(0.1)	–	–	–	–	–	–
Public	33.1%	1.7	(0.0)	3.5	(0.1)	1.8	(0.1)	–	–	–	–	–	–
Practice type[c]		*				*							
General	91.0%	1.4	(0.0)	3.7	(0.1)	2.2	(0.1)	0.46	(0.40,0.53)	1.14	(0.98,1.32)	1.59	(1.27,2.00)
Specialist	9.0%	2.9	(0.5)	3.4	(0.3)	1.5	(0.2)	ref		ref		ref	
Length of service													
<2 years	54.7%	1.5	(0.1)	3.7	(0.1)	2.2	(0.1)	0.98	(0.88,1.08)	1.03	(0.94,1.13)	1.03	(0.91,1.17)
2+ years	45.3%	1.6	(0.1)	3.6	(0.1)	2.1	(0.1)	ref		ref		ref	
Team size													
1 - 2 practitioners	11.9%	1.4	(0.1)	3.9	(0.2)	2.0	(0.1)	0.85	(0.72,1.00)	1.09	(0.94,1.26)	0.99	(0.80,1.22)
3 - 7 practitioners	64.3%	1.5	(0.1)	3.7	(0.1)	2.2	(0.1)	0.87	(0.78,0.97)	1.02	(0.92,1.13)	1.02	(0.88,1.18)
8 or more practitioners	23.8%	1.7	(0.1)	3.5	(0.2)	2.1	(0.1)	ref		ref		ref	
Proportion child patients		*				*							
<80% children	71.4%	1.5	(0.1)	3.7	(0.1)	2.3	(0.1)	ref		ref		ref	
80%+ children	28.6%	1.8	(0.1)	3.4	(0.1)	1.7	(0.1)	1.08	(0.97,1.21)	0.95	(0.86,1.05)	0.82	(0.71,0.95)
Region of practice													
Major City	73.4%	1.5	(0.1)	3.7	(0.1)	2.2	(0.1)	0.93	(0.79,1.09)	0.98	(0.85,1.14)	1.06	(0.85,1.31)
Inner Regional	18.0%	1.8	(0.2)	3.4	(0.2)	1.8	(0.1)	1.12	(0.93,1.35)	0.88	(0.74,1.04)	0.87	(0.68,1.11)
Outer Regional /remote	8.6%	1.5	(0.1)	3.8	(0.2)	2.1	(0.1)	ref		ref		ref	
Overall	100.0%	1.6	(0.1)	3.7	(0.1)	2.1	(0.1)						

[a] Asterisk (*) indicates that means were statistically different. Comparisons were assessed by negative binomial regression models; each variable was assessed in a separate model with no adjustment for other variables, significance based on 95%CIs not including 1.0.

[b] Adjusted Rate Ratios (RR) were estimated from negative binomial regression models, RR exp(β). With the exception of sector of practice, all explanatory variables were included in the model. Significance based on 95%CIs not including 1.0.

[c] Practitioners classified into three registration groups based on AIHW registration categories (AIHW, 2014). 'General' practice types included, private general practice, school dental services, dental hospitals, health fund clinics, community health centres, Australian Defence Forces. 'Specialist' practice types included orthodontic, periodontal, paediatrics, prosthodontic, endodontic and special needs practices.

Table 2. Dental Hygienists: patient visits per hour and services per patient visit by practitioner demographics and practice characteristics

Characteristics		*Unadjusted associations*						*Adjusted associations*					
		Patients per hour		*Total services per patient*		*Preventive services per patient*		*Patients per hour*		*Total services per patient*		*Preventive services per patient*	
	Distributions	*Mean*[a]	*(SE)*	*Mean*[a]	*(SE)*	*Mean*[a]	*(SE)*	*RR*[b]	*95%CI*	*RR*[b]	*95%CI*	*RR*[b]	*95%CI*
Age group (years)	n=336												
<30	26.4%	1.6	(0.1)	3.7	(0.2)	2.1	(0.1)	ref		ref		ref	
30–39	36.2%	1.7	(0.1)	3.3	(0.1)	2.0	(0.1)	0.99	(0.88,1.12)	0.97	(0.86,1.08)	1.08	(0.90,1.28)
40–49	25.2%	1.5	(0.2)	3.6	(0.2)	2.0	(0.1)	0.90	(0.79,1.03)	1.04	(0.92,1.17)	1.10	(0.91,1.32)
50+	12.2%	1.4	(0.1)	3.7	(0.2)	2.2	(0.1)	0.92	(0.79,1.07)	1.05	(0.91,1.22)	1.13	(0.90,1.41)
Sector of practice													
Private	96.1%	1.6	(0.1)	3.5	(0.1)	2.0	(0.1)	–	–	–	–	–	–
Public	3.9%	1.2	(0.1)	4.3	(0.2)	2.7	(0.1)	–	–	–	–	–	–
Practice type [c]		*		*		*							
General	79.5%	1.2	(0.0)	3.8	(0.1)	2.4	(0.0)	0.45	(0.40,0.51)	1.60	(1.43,1.80)	3.28	(2.71,3.96)
Specialist	20.5%	3.1	(0.3)	2.4	(0.2)	0.8	(0.1)	ref		ref		ref	
Length of service													
<2 years	28.6%	1.5	(0.1)	3.7	(0.2)	2.1	(0.1)	0.91	(0.82,1.01)	1.07	(0.97,1.18)	1.04	(0.90,1.22)
2+ years	71.4%	1.6	(0.1)	3.5	(0.1)	2.1	(0.1)	ref		ref		ref	
Team size		*											
1 - 2 practitioners	9.2%	1.6	(0.2)	3.4	(0.2)	1.9	(0.2)	0.84	(0.71,1.00)	1.00	(0.85,1.18)	0.89	(0.69,1.15)
3 - 7 practitioners	68.2%	1.5	(0.1)	3.6	(0.1)	2.2	(0.1)	0.88	(0.79,0.98)	1.03	(0.93,1.14)	1.04	(0.89,1.22)
8 or more practitioners	22.6%	1.9	(0.2)	3.4	(0.2)	1.9	(0.1)	ref		ref		ref	
Proportion child patients		*		*		*							
<80% children	91.7%	1.4	(0.1)	3.7	(0.1)	2.2	(0.0)	ref		ref		ref	
80%+ children	8.3%	3.5	(0.5)	2.3	(0.3)	0.9	(0.2)	1.48	(1.27,1.72)	0.82	(0.69,0.96)	0.76	(0.58,0.99)
Region of practice		*		*									
Major City	86.0%	1.6	(0.1)	3.5	(0.1)	2.0	(0.1)	1.02	(0.83,1.25)	0.89	(0.74,1.06)	0.93	(0.71,1.22)
Inner Regional	8.0%	1.4	(0.1)	3.4	(0.3)	2.2	(0.2)	1.11	(0.87,1.43)	0.81	(0.65,1.02)	0.87	(0.62,1.22)
Outer Regional /remote	6.0%	1.1	(0.0)	4.4	(0.4)	2.5	(0.2)	ref		ref		ref	
Overall	100.0%	1.6	(0.1)	3.5	(0.1)	2.1	(0.1)						

[a] Asterisk (*) indicates that means were statistically different. Comparisons were assessed by negative binomial regression models; each variable was assessed in a separate model with no adjustment for other variables, significance based on 95%CIs not including 1.0.

[b] Adjusted Rate Ratios (RR) were estimated from negative binomial regression models, RR exp(β). With the exception of sector of practice, all explanatory variables were included in the model. Significance based on 95%CIs not including 1.0.

[c] Practitioners classified into three registration groups based on AIHW registration categories (AIHW, 2014). 'General' practice types included, private general practice, school dental services, dental hospitals, health fund clinics, community health centres, Australian Defence Forces. 'Specialist' practice types included orthodontic, periodontal, paediatrics, prosthodontic, endodontic and special needs practices.

Table 3. Dental Therapists: patient visits per hour and services per patient visit by practitioner demographics and practice characteristics

Characteristics		*Unadjusted associations*						*Adjusted associations*					
		Patients per hour		*Total services per patient*		*Preventive services per patient*		*Patients per hour*		*Total services per patient*		*Preventive services per patient*	
	Distributions	*Mean*[a]	*(SE)*	*Mean*[a]	*(SE)*	*Mean*[a]	*(SE)*	*RR*[b]	*95%CI*	*RR*[b]	*95%CI*	*RR*[b]	*95%CI*
Age group (years)	n=223	*											
<30	8.1%	2.4	(0.4)	3.2	(0.2)	1.8	(0.2)	ref		ref		ref	
30–39	14.3%	1.7	(0.2)	3.4	(0.2)	2.0	(0.1)	0.74	(0.60,0.92)	1.08	(0.86,1.35)	1.14	(0.80,1.63)
40–49	32.3%	1.8	(0.1)	3.2	(0.1)	1.7	(0.1)	0.69	(0.57,0.84)	1.01	(0.83,1.24)	0.99	(0.72,1.37)
50+	45.3%	1.9	(0.1)	3.5	(0.2)	1.8	(0.1)	0.73	(0.61,0.88)	1.10	(0.90,1.34)	1.08	(0.78,1.48)
Sector of practice													
Private	35.4%	1.8	(0.1)	3.4	(0.1)	1.9	(0.1)	–	–	–	–	–	–
Public	64.6%	1.9	(0.1)	3.3	(0.1)	1.7	(0.1)	–	–	–	–	–	–
Practice type [c]		*		*		*							
General	93.7%	1.8	(0.1)	3.4	(0.1)	1.9	(0.1)	0.50	(0.43,0.58)	1.44	(1.18,1.76)	2.15	(1.54,3.01)
Specialist	6.3%	3.6	(0.5)	2.3	(0.3)	0.9	(0.3)	ref		ref		ref	
Length of service													
<2 years	14.3%	2.0	(0.2)	3.4	(0.2)	1.8	(0.1)	0.98	(0.86,1.11)	1.05	(0.91,1.21)	1.06	(0.85,1.34)
2+ years	85.7%	1.9	(0.1)	3.3	(0.1)	1.8	(0.1)	ref		ref		ref	
Team size		*											
1 - 2 practitioners	33.2%	2.0	(0.1)	3.3	(0.1)	1.7	(0.1)	1.13	(0.99,1.28)	0.95	(0.83,1.10)	0.90	(0.72,1.12)
3 - 7 practitioners	45.3%	1.9	(0.1)	3.3	(0.1)	1.8	(0.1)	1.11	(0.98,1.25)	1.00	(0.88,1.13)	0.97	(0.79,1.19)
8 or more practitioners	21.5%	1.6	(0.1)	3.4	(0.2)	1.9	(0.2)	ref		ref		ref	
Proportion child patients		*				*							
<80% children	26.9%	1.5	(0.1)	3.5	(0.1)	2.1	(0.1)	ref		ref		ref	
80%+ children	73.1%	2.0	(0.1)	3.3	(0.1)	1.7	(0.1)	1.44	(1.29,1.61)	0.91	(0.80,1.03)	0.76	(0.63,0.93)
Region of practice				*									
Major City	59.2%	1.9	(0.1)	3.2	(0.1)	1.7	(0.1)	1.14	(0.99,1.31)	0.84	(0.73,0.98)	0.76	(0.60,0.96)
Inner Regional	26.9%	1.9	(0.1)	3.4	(0.2)	1.8	(0.2)	1.08	(0.93,1.26)	0.87	(0.74,1.03)	0.81	(0.63,1.05)
Outer Regional /remote	13.9%	1.7	(0.1)	3.7	(0.3)	2.1	(0.2)	ref		ref		ref	
Overall	100.0%	1.9	(0.1)	3.3	(0.1)	1.8	(0.1)						

[a] Asterisk (*) indicates that means were statistically different. Comparisons were assessed by negative binomial regression models; each variable was assessed in a separate model with no adjustment for other variables, significance based on 95%CIs not including 1.0.

[b] Adjusted Rate Ratios (RR) were estimated from negative binomial regression models, RR exp(β). With the exception of sector of practice, all explanatory variables were included in the model. Significance based on 95%CIs not including 1.0.

[c] Practitioners classified into three registration groups based on AIHW registration categories (AIHW, 2014). 'General' practice types included, private general practice, school dental services, dental hospitals, health fund clinics, community health centres, Australian Defence Forces. 'Specialist' practice types included orthodontic, periodontal, paediatrics, prosthodontic, endodontic and special needs practices.

Alternate models

For each practitioner group and service provision outcome, alternate models were constructed. The first alternate model series (A) included sector but excluded proportion child patients, and the second model series (B) included both sector of practise and proportion child patients.

In alternate models (A), for the DT and OHT groups, the pattern of associations observed for sector was consistent with the associations observed for proportion child patients (presented in Table 1 and Table 3). DTs and OHTs in the public sector had a significantly higher patient rate (RRs 1.2 and 1.4 respectively) and significantly lower preventive rate (RRs 0.8 and 0.7 respectively) than those in the private sector. Also consistent with models presented in tables, service rates were not associated with sector.

In alternate models (B), DTs with more than 80% child patients had a significantly higher patient rates (RR 1.3) but sector was not significantly associated. In contrast, for OHTs, those in the public sector had a significantly higher patient rate (RR 1.2) but rates did not vary significantly by proportion child patients. For both DTs and OHTs, neither sector nor proportion of children, were significantly associated with service or preventive rates. Therefore, consistent with the two factors being highly correlated, when both factors were accounted for, observed effects were diminished.

Only 3.9% of DHs were in the public sector, consequently, for additional models (A) and (B), sector was not associated with any of the service provision outcomes and did not result in any differences in the pattern of associations presented in Table 2.

Retest

A retest was conducted to assess potential for bias in reporting of service provision (results not presented). Response rate was 44% (n=35). The mean rates of patients per hour were marginally higher for OHTs reporting their service provision over a usual working week (retest questionnaire) than the rates calculated from their reporting of a self-selected day (patients per hour: 1.6 versus 1.5 respectively). In contrast, mean services and preventive services per patient visit were marginally lower for the one week log than the one day log (all services: 5.0 versus 5.4, preventive services: 2.7 versus 2.9). However, based on 95% confidence intervals, differences were not significant.

Discussion

Dental workforce supply models require practice activity estimates. Apart from some public sector administrative data, generally service provision estimates have not been available for DH, DT, OHTs. Previous modelling attempts have relied on substituting dentist service rates or estimations based on expert opinion. Hence, a key aim of this study was to provide service provision rates appropriate for application in Australian workforce modelling or modelling in countries with similar dental health systems (i.e. similar practitioner types practising in a mix of public and private settings). In addition, understanding variations in these rates may identify key variables that should be incorporated into modelling. The main finding of this study was that for all three groups, patient and preventive rates varied by practice type and proportion of children treated. Practitioners who treated mostly children in a typical day of practice had lower preventive rates than those who treated fewer children. In addition, there were substantial differences in preventive rates by practice type, with those in general practice having higher rates than those working in specialist practice. The findings indicate that the age distribution of patients treated and practice type are variables that should be considered in projection models of service delivery, particularly if these variables were expected to change over time, (e.g. in response to a policy reform). Some other associations were observed but were not consistent across all three groups.

Variations in preventive and patient rates were consistent with other known factors of dental practice. In terms of practice type, the majority of practitioners working in specialist practice are predominantly employed in orthodontic practice (AIHW, 2014). Hence the differences observed between specialist and general practice were likely to be a reflection of the service patterns in orthodontic practice. Practitioners in orthodontic practice are less likely to be involved in delivering preventive services and have higher patient rates than general practice (Matthew *et al*., 2005). Further, differences in preventive rates by proportion of child patients may be explained by lower demand for scale and cleans; children generally have less calculus build up than adults. While lower preventive rates may be understandable, it may still raise public health debate around whether the rate of preventive services observed is appropriate. Further exploration of whether rates of fissure sealants and topical fluorides are being provided at levels necessary to achieving child population health goals should be explored.

There was a high correlation between practice sector and proportion of child patients treated, consequently models with, and without, sector were constructed. The alternate models largely found a similar pattern of associations between sector and service provision to what was observed for the variable *proportion of child patients*. While this may indicate (in the Australian context) that these variables can be considered proxies for one another, it should be noted that this assumption may not hold in the future. The proportion of child patients seen by OHTs in private practice may increase in response to the introduction of The Child Dental Benefits Schedule (CDBS) (Department of Health, Australian Government, 2014). Conversely, the proportion of adults treated by OHTs or DTs in the public sector may increase as a result of an increase in numbers of practitioners' with expanded practise capacity and qualifications to treat adults. Further, there are numerous differences between the two sectors which may influence patterns of service provision, such as differences in clinical guidelines and socioeconomic status of patients (Brennan *et al*., 2008; Brennan and Spencer, 2005). Further research exploring if sector of employment has independent associations with service provision is required.

The preventive rates for DHs, DTs and OHTs were relatively high compared to those provided by dentists. Estimates of preventive rates for Australian general dentists (2003-04) ranged from 0.1 to 0.8 across age groups, with 12 to 17 year olds having the highest rate (Brennan and Spencer, 2006). These dentist rates are much lower than the preventive rates for all three practitioner groups in our study (OHT: 2.2; DH: 2.1; DT: 1.8). This finding reflects the differences in the orientation of service provision between oral health practitioners and dentists.

A previous study on the same sample showed that more than a third of all preventive services provided by these practitioners were oral health instruction (OHI) (Teusner *et al*., 2015) and therefore the frequent provision of OHI may contribute to the comparatively higher preventive rate.

As the three groups vary markedly in their distribution across practice settings, statistical comparisons between the groups were not conducted. Analyses focused on assessing associations between rates and practice characteristics for each group separately. However, overall estimated rates varied little across the three groups. One observed difference was that DTs had a higher mean patient rate and a lower mean service rate than DHs and OHTs. While services per hour estimates were not presented, they can be readily calculated from reported means (mean patient rate multiplied by mean service rate). Calculations of services per hour showed that OHTs and DHs had similar rates of services per hour and the rate for DTs was slightly higher (OHT=5.7, DH=5.6 and DT=6.3 services per hour).

The sampling frame for this study covered approximately 58% of the DH, DT, OHT workforce (Australian Institute of Health and Welfare, 2014). While this study had acceptable response and a sufficient number of observations for analysis, not all practitioners working in clinical practice provided complete data. However, comparison of key characteristics did not indicate a potential for response bias. Furthermore, comparison of the distributions of practitioners (included in analysis) across age groups, sector and practice type, were broadly similar to national estimates (AIHW, 2014), indicating reasonable generalisability within Australia. In addition, a retest on a subsample of OHTs indicated a low likelihood of bias associated with collection on a self-selected clinical day.

Conclusion

While there were some differences in the pattern of associations between service provision rates and practice characteristics across the three registration groups, for all three groups preventive service rates varied significantly by type of practice and the proportion of child patients treated. These findings indicate that practice type and the age distribution of patients are variables that should be considered in oral health service delivery planning for these groups, particularly if these variables were expected to change over time. Another key variable was the sector of practice worked (public or private). Further research is required to explore if sector of practice is a proxy for proportion child patients or whether it independently influences variations in service rates. The service provision rates, estimated in this study, could be applied in workforce modelling for countries with similar dental health systems. Rates may be of particular use in modelling that aims to understand how variations in the composition of the workforce will impact on aggregate dental service provision. However, while these rates may reflect services delivered under current models of care in Australia, these rates may not represent the optimal use of these practitioners in order to achieve population health goals.

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