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The Contributions of Dental Therapists and Advanced Dental Therapists in the Dental Centers of Apple Tree Dental in Minnesota

CHWS
Center for Health Workforce Studies
School of Public Health
University at Albany, State University of New York

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PREFACE

The Center for Health Workforce Studies (CHWS) at the University at Albany School of Public Health completed a study to evaluate how the dental therapy workforce has affected access to oral health services and oral health outcomes for patients at Apple Tree Dental in Minnesota as well as the impact of the workforce on practice configurations, team productivity and practice efficiency. This study examined the subset of dental therapists/advanced dental therapists in Minnesota working at the dental centers of Apple Tree Dental between 2012 and 2019 to describe the patients served and the services provided by the dentists and the dental therapists/advanced dental therapists at these centers.

This report was prepared by Margaret Langelier, Simona Surdu, and Jean Moore with layout design by Leanne Keough. Yuhao Liu completed the data analyses. This work is supported by the Pew Charitable Trusts.

Established in 1996, CHWS is an academic research center, based at the School of Public Health, University at Albany, State University of New York (SUNY). The mission of CHWS is to provide timely, accurate data and conduct policy relevant research about the health workforce. The research conducted by CHWS supports and promotes health workforce planning and policymaking at local, regional, state, and national levels. Today, CHWS has established itself as a national leader in the field of health workforce studies.

The views expressed in this report are those of CHWS and do not necessarily represent positions or policies of the School of Public Health, University at Albany, SUNY, or the Pew Charitable Trusts.

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Institutional Review Board

The plan for this study was reviewed and designated exempt from further review by the Institutional Review Board of the New York State Department of Health (Study No. 1519602-01).

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BACKGROUND

Equitable access to oral health services was a benchmark goal set by the Surgeon General at the turn of the 21st century. However, 2 decades since this call to action, access to oral health services eludes many. The barriers to achievement are grounded in the complexities of geography, issues of cultural, ethnic, and racial diversity, and in economic conditions affecting the delivery system and individuals seeking care.

Oral health stakeholders in Minnesota were attentive to the unmet oral health needs of a significant proportion of the state's population when in 2008 they introduced legislation to enable a new type of oral health professional intended to bridge gaps in care. In 2009, the legislature, with support from diverse and divergent stakeholders, passed a bill creating a new workforce to be trained and licensed as dental therapists with 2 different levels of dental supervision. A dental therapist would practice under direct or indirect supervision. A dental therapist with a graduate degree, 2,000 hours of clinical experience, and competency testing could be certified as an advanced dental therapist to provide an expanded set of services and work under general supervision. The main purpose of this workforce was to act as a point of entry to the oral health care system for historically underserved populations in the state, defined as low-income populations, the Medicaid insured, special needs populations, those living in dental health professional shortage areas, and others with compromising medical conditions.

Apple Tree Dental is a large non-profit community dental provider that began operation in 1985 as a mobile dental program serving the elderly in and around Minneapolis and St. Paul, Minnesota. The organizational mission focuses on oral health for all by removing barriers to care; as a result, the provider has grown substantially during its 35-year history. Apple Tree Dental now operates seven centers for dental health (centers) in urban and rural areas throughout the state. The organization continues to support a substantial mobile dental program providing dental services in 145 locations in Minnesota including skilled nursing facilities, elder care centers, Head Start programs, group homes, and day habilitation programs. Patients at Apple Tree Dental comprise all age groups, many of whom have special health care needs, and the vast majority of whom are low-income and Medicaid eligible. Apple Tree Dental was among the initial employers of dental therapists in late 2011 and early 2012, when the first dental therapy students completed didactic and clinical education, competency evaluation, and licensure. Currently, Apple Tree Dental employs 34 dentists, 10 dental therapists/advanced dental therapists and 30 dental hygienists, including 4 serving in administrative roles.

Interest exists in understanding how introduction of the dental therapy workforce to oral health care teams has impacted service mix, the quantity and quality of care, the efficiency of care delivery, and the capacity of the delivery system to address need for oral health services. This study was quantitative and examined patient encounter data from Apple Tree Dental to describe and compare the type and quantity of services provided by dentists in their dental centers before and after introduction of dental therapy to the practices at the dental centers and to describe the services provided by dental therapists and advanced dental therapists since Apple Tree Dental first employed this workforce. This report focuses mainly on the overlaps in services, particularly restorative services, provided by dentists, dental therapists/advanced dental therapists.

METHODS

This study examines encounter data that include more than a quarter of a million encounters for 76,342 patients obtaining care in one of the 7 dental centers operated by Apple Tree Dental in Minnesota. Data from Apple Tree's mobile program was excluded from this analysis.

The encounter data supplied by Apple Tree Dental were for services provided beginning February 9, 2009 (3 years prior to the first employment of a dental therapist at the organization) through July 31, 2019, a date agreed upon in the study contract. This time span provided adequate data for researchers to compare summary production of the oral health workforce across the centers of Apple Tree Dental.

All tables and figures depicting dentists' services describe data for each of the 3 years prior to practice with a dental therapist and for the more than 7 years since that practice was initiated. All data for dental therapists

is reported for each of the 7 years subsequent to their initial employment in early 2012. All data for advanced dental therapists is reported for each of the 6 years since the first dental therapist qualified for advanced certification after 2,000 hours of practice and competency testing beginning in 2013.

The encounter data include the date of service, the services rendered, the profession of the clinical provider, and the characteristics of the patients (ie, demographics and insurance) for each of the encounters examined. Over the study period, 15 dental therapists worked for the organization along with dentists and dental hygienists. Ten of these dental therapists also held licensure as dental hygienists; 5 did not.

The study outcomes include a description of types of services performed by dentists and dental therapists/advanced dental therapists and changes in intensity and distribution of those services described in terms of Relative Value Units (RVUs). An RVU is an aggregate number that represents a sum of values attributed to various aspects of a dental procedure including the extent of professional training required to perform the service, the complexity of the skills necessary to execute, and the costs of required resources and materials among others. For example, a topical fluoride treatment has a lower RVU than a root canal in a posterior molar. Applicable RVU values compiled nationally were assigned to each procedure in the Apple Tree Dental encounter data based on the current dental terminology (CDT) code that described the service. RVUs were then summed to determine the average daily production value and intensity of services provided by dentists, dental therapists, and advanced dental therapists over time, including the 3-year period before and the 7-year period after introduction of dental therapy to a dental center practice.

Researchers were also interested in understanding the economic impact of dental therapy practice on organizational revenue before and after their introduction to the dental centers. A standardized fee schedule developed by the American Dental Association based on national surveys of dentists was used to achieve this analysis. The national average fees in the Survey of Dental Fees 2018[1] were consistently applied to the dental encounter data in the Apple Tree Dental database based on the CDTs in the files. Applying the 2018 fee schedule to all years since 2009 permitted for inflation adjustment to actual fees generated in earlier years and allowed for reasonable comparisons in fees across years. This data was used to describe changes in economic production by members of the dental team over the period of the study.

Various statistical data analyses (ie, frequency, percentage, t-test, chi-square test, and trend estimates using linear regression) were used to compare the quantity and type of services performed by dentists before and after introduction of dental therapists/advanced dental therapists to the clinical team. Dental services were organized into categories based on procedure code groupings in current dental terminology. The data is reported using provider treatment days as the denominator in many of the equations that describe the contributions of the various oral health professionals to patient care.

Summing and describing the data for each of the seven dental centers proved to be a complex undertaking because not all were established prior to introduction of dental therapists to the organization so prior year data were unavailable. In addition, the timelines related to employment of dental therapists varied in each, with some having periods when no dental therapist was practicing in the center. Researchers determined that an extensive, detailed analysis of 2 of the 7 dental centers would yield the most useable findings because these centers had the most comprehensive and continuous data describing dental therapy practice. Each of the 2 centers had 3 years of operational data prior to employing a dental therapist and each had continually used one or more dental therapists to provide services beginning in 2012. In addition, the 2 centers were in different geographical locations. The Coon Rapids center is located in an urban area and the Madelia center is located in rural Minnesota. The analysis specific to these 2 locations is described in this report.

KEY FINDINGS

Production Generated by Dentists Measured by Numbers of Procedures

Dentists' production by number of services/procedures was calculated per treatment day in the years before and after dental therapists joined the clinical teams.

- The data show a decrease in the average number of procedures per treatment day 3 years immediately after introduction of dental therapists to the clinical teams from an average of 21.69 in 2009-10 to 19.84 in 2014-15 with a subsequent gradual increase to 25.61 procedures per day in 2018-19.

- The positive 10-year trend in average number of procedures produced by a dentist per treatment day was not statistically significant (P=0.164). However, the increasing trend in the average number of procedures per treatment day by a dentist after introduction of dental therapists to the clinical teams was statistically significant (P<0.001).

- Over the 10-year period, the absolute number of procedures varied in all categories of service due in part to the variation in number of treatment days per year. The most common procedures in all years were classified as diagnostic or restorative services.

- The distribution by type of dental procedure varied as a percentage of the total procedures performed in an average treatment day. The proportion of an average workday given to restorative procedures began to diminish in the 2 years prior to and the 3 years immediately following introduction of dental therapy from 32.2% in 2009-10 to 29.0% in 2015-16 but returned to pre-dental therapy levels beginning in 2016-17. In 2018-19, restorative procedures represented, on average, 33.8% of procedures performed per treatment day.

- Changes in the proportion of procedures performed by a dentist per treatment day over the 10-year period were not statistically significant except for the positive trend in prosthodontic procedures (P=0.022) and the negative trend in periodontic procedures (P=0.044).

Production Generated by Dentists Described by Relative Value Units

The intensity of dentists' services changed over the period of time examined for this research. In all years after introduction of dental therapists, the RVUs produced by a dentist per treatment day met or exceeded those generated in the pre-dental therapy years.

- Dentists' production showed an increase in service intensity over the 10-year period with an average of 51.56 RVUs produced per treatment day by a dentist in 2009-10 progressing to an average of 60.19 RVUs per treatment day in 2018-19.

- In the 3-year period prior to the introduction of dental therapists (2009 to 2012), average RVUs per treatment day were 51.56, 48.20, and 46.42, respectively. In the most recent 3-year post dental therapy period (2016 to 2019), average RVUs per treatment day were 50.02, 57.71, and 60.19, respectively.

- Restorative services generated the highest proportion of average RVUs per treatment day in every year examined for this study (43.0% in 2009-10; 50.5% in 2018-19).

- The trend in average RVUs per dentist treatment day over the 10-year period was positive and statistically significant (P=0.013).

- In 2009-10, dentists completed 10.9 patient visits on average per treatment day; that number increased to 13.8 in 2018-19 at the same time that the average daily production value for visits also increased. The positive trend in the proportion of patient visits was statistically significant (P=0.018).

- In 2018-19, 35.8% of the patient visits completed by dentists were for children under 18 years of age compared to 24.7% in 2009-10. The positive trend in the proportion of children's visits was statistically significant (P=0.004).

Production Generated by Dentists Described by Average Fees from Procedures

Fees for services by dentists increased on average per treatment day in all years since the introduction of dental therapists to the clinics.

- Average fees per treatment day increased from $3,604.52 in 2009-10 (adjusted to 2018 fee levels) to an average of $4,194.01 per treatment day in 2018-19.

- The positive trend in the average fees per dentist treatment day between 2009 and 2019 was statistically significant (*P*=0.014).

- Almost half (49.9%) of fees generated by dentists in 2018-19 were from restorative procedures. Fees from restorative, prosthodontic, and diagnostic procedures represented the majority of fees from dental services in 2018-19.

- The trends in the proportions of fees by procedure type over the 10-year period were not statistically significant except for the negative trends in the proportion of fees generated by periodontic services (*P*=0.001).

Dental Therapists/Advanced Dental Therapists

The introduction of dental therapists at Apple Tree in 2011-12 occasioned an increase in overall production of services due to greater workforce capacity in the 2 dental centers. In 2012-13, there were no advanced dental therapists in either of the 2 centers since certification required a period of supervised practice postgraduation. In 2014-17 there were no dental therapists in either location; all therapists in the centers in those years had earned advanced certification.

The data showed that the contributions of dental therapists differed somewhat from that of advanced dental therapists likely attributable, at least in part, to differences in levels of required supervision, allowances that permit advanced dental therapists more expansive tasks, and years of experience working in dental therapy.

Production Generated by Dental Therapists and Advanced Dental Therapists Measured by Numbers of Procedures

- Dental therapists gradually provided a higher number of procedures, on average, per treatment day over the study period (from 14.31 procedures in 2012-13 to 19.35 in 2018-19) with the exception of the years between 2014 and 2017 when there were no dental therapists in the 2 centers examined for this study. The positive trend in average procedures per dental therapist treatment day was statistically significant (*P*=0.002).

- In 2018-19, half of all procedures provided by dental therapists in the two Apple Tree centers were preventive (49.6%).

- Restorative procedures constituted 43.2% of all services supplied by dental therapists in 2012-13. Restorative services comprised 34.5% of services in 2017-18 and 14.2% of services supplied to patients by dental therapists in 2018-19.

- Changes in the proportion of procedures by type over the 10-year period were not statistically significant.

- The average number of patient visits per dental therapist treatment day increased from 5.8 in 2012-13 to 7.0 in 2018-19; the increasing trend was not statistically significant.

- In 2018-19, 48.3% of the patient visits completed by dental therapists were for children under 18 years of age compared to 43.8% in 2012-13. The positive trend in the proportion of children's visits was not statistically significant (*P*=0.434).

Advanced dental therapists provided a wide range of procedures over the 6-year period after the first dental therapists were certified for advanced status.

- The average number of procedures per advanced dental therapist treatment day increased from an average of 20.24 in 2013-14 to 27.77 in 2018-19. The positive trend in average number of procedures per advanced dental therapist treatment day was statistically significant (*P*=0.028).

- The highest average number of procedures per treatment day (29.16) occurred in 2016-17, the same year in which the average number of procedures by dentists in the 2 centers was lowest due to dental staff transitions.

- In 2018-19, advanced dental therapists provided a 2 times higher proportion of restorative services (28.9%) than dental therapists (14.2%).

- The proportion of restorative services provided by an advanced dental therapist per treatment day decreased from 36.4% in 2013-14 to 28.9% in 2018-19. The negative trend in proportion of restorative services by advanced dental therapists per treatment day was statistically significant ($P<0.001$).

- The average number of patient visits per treatment day by an advanced dental therapist increased from 8.2 in 2013-14 to 13.0 in 2018-19; the increasing trend was borderline statistically significant ($P=0.055$).

- In 2018-19, 63.4% of the patient visits completed by advanced dental therapists were for children under 18 years of age compared to 47.4% in 2013-14. The positive trend in the proportion of children patient visits was statistically significant ($P=0.003$).

Production Generated by Dental Therapists and Advanced Dental Therapists Described by Relative Value Units

- Average RVUs per treatment day produced by dental therapists were 24.07 in 2012-13 and 24.41 in 2018-19. The positive trend in RVUs produced by dental therapists was not statistically significant ($P=0.923$).

- Restorative services represented 14.2% of all procedures provided by dental therapists for patients in 2018-2019 but accounted for 33.6% of RVUs generated per treatment day. In all other years (2012 to 2018) during which dental therapists were practicing in the 2 clinics, restorative services represented between 61% and 74% of RVUs produced per treatment day by dental therapists.

- Preventive services represented 49.6% of patient services provided by dental therapists and 38.2% of RVUs in 2018-19.

- RVUs for restorative services to patients represented the majority of RVUs (58% to 63%) produced by advanced dental therapists, on average per treatment day in all years examined for this study.

- The positive trend in RVUs for all services by advanced dental therapists was statistically significant ($P=0.029$).

- In 2018-19, restorative procedures represented 28.9% of procedures provided to patients by advanced dental therapists but 57.8% of average daily RVUs for advanced dental therapy services.

Production Generated by Dental Therapists and Advanced Dental Therapists Described by Average Fees from Procedures

Average fees per dental therapist's treatment day varied by year in the 2 clinics.

- The average fees per treatment day ($1,712.98) in 2018-19 were similar to those generated in the first year in which dental therapists were introduced to practice ($1,764.67 in 2012-13). The change in average fees per treatment day was not statistically significant ($P=0.892$).

- In the first year of practice at Apple Tree Dental, 71.0% of the fees generated from dental therapists' services were for restorative procedures. In 2018-19, 34.7% of fees generated by dental therapists were for restorative services provided to patients.

- More than a third of fees generated (36.9%) in 2018-19 were for preventive services supplied by dental therapists.

- The trends in the proportion of fees generated by dental therapists by procedure type over the 10-year period were not statistically significant except for the positive trend in adjunctive services that was borderline statistically significant ($P=0.056$).

Average fees per advanced dental therapist's treatment day increased over time.

- Average fees per treatment day were higher in 2018-19 ($3,065.06) than in 2013-14 ($2,341.35), the first year in which advanced dental therapists were in the

centers. The positive trend in average fees was statistically significant (*P*=0.011).

- In 2018-19, 57.4% of fees generated by advanced dental therapists were for restorative services. In that year, restorative procedures represented 28.9% of services provided by advanced dental therapists and they accounted for 57.8% of average daily RVUs.

- In 2018-19, 19.4% of fees generated by advanced dental therapists were for preventive services. Preventive services represented 33.3% of procedures by advanced dental therapists but accounted for only 20.0% of RVUs produced by advanced dental therapists in that year.

- The trends in the proportion of fees by procedure type over the 10-year period were not statistically significant except for the negative trend in proportion of fees for restorative services produced by advanced dental therapists (*P*=0.008).

The 7 Dental Clinics of Apple Tree Dental

To ascertain if the findings from the 2 centers at Apple Tree Dental with the most consistent and continuous data related to deployment of dental therapists/advanced dental therapists were reasonable and generally representative of organization wide practice, a summary analysis of all patient encounter data for the ten year period beginning February 9, 2009 and ending July 31, 2019 in the 7 clinics was conducted. The findings from the 2 centers were also compared in a separate analysis to the findings from the other 5 centers. Both analyses revealed that the data from the subset of 2 centers were consistent with organization-wide outcomes from deployment of dental therapists/advanced dental therapists.

DISCUSSION

Apple Tree Dental mainly serves low-income patients, many of whom are Medicaid eligible and a portion of whom have special health care needs. The organization largely depends on reimbursement from public insurance programs to support operations and patient services. Thus, maximizing clinical and operational capacity is critical to sustaining the organization's centers and mobile dental services. Administrative and clinical staff at Apple Tree Dental are committed to the organizational mission of serving people with special dental access needs who may experience barriers to oral health services. To achieve this goal, Apple Tree Dental has built clinical and administrative teams to efficiently deploy workforce and effectively use divergent and overlapping professional competencies to address patient need.

The study findings suggest that, at a minimum, capacity to provide services has increased across the organization, due in part to new workforce and, as a result, access to dental services at Apple Tree Dental has increased. A previous study in Minnesota of other providers employing dental therapists found that dental therapists in those practices were expanding access to dental services in both rural and metropolitan areas of the state.[2] The number of patients and clinicians in the Apple Tree Dental centers increased concomitant with the introduction of dental therapists to the organization. Over the study period, the demographics of the patient population changed with an increase in the number of children served.

Organizational capacity also grew in terms of number of dental centers, expansion of catchment area, and employment of clinical professionals to provide services. There are currently 34 dentists and 10 dental therapists/advanced dental therapists employed by the organization. While we cannot directly attribute increased capacity at Apple Tree Dental to the introduction of dental therapists to practice, it is apparent that their presence in the dental centers and their clinical skills have contributed to the ability of the organization to meet the needs of their expanding patient caseload.

This study examined the quantity, type, and relative value of services provided by clinical oral health professionals before and after introduction of dental therapy practice at Apple Tree Dental. In summary, the analyses showed that the addition of the dental therapy workforce has had positive outcomes for patients, providers, and the organization generally. The statistics demonstrate that currently dentists are seeing more patients, providing more services, and producing higher average RVUs and fees per treatment day than in the years prior to introduction of dental therapy. The number of patient visits per day, the number of services provided, and the service values (RVUs) for dental therapists/advanced dental therapists have

also increased subsequent to their first years of employment suggesting that clinical experience and full integration into the dental teams has enhanced their contributions to patient services over time.

This report focuses on workload, with an emphasis on describing restorative services which represent the intersection or overlap of skills for dental therapists/advanced dental therapists with dentists. One of the findings from this study is that while the distribution of services by type has not changed substantially since the dental therapy workforce joined the dental teams, the value of the services provided within different procedural categories has increased. Approximately one-third of procedures performed by dentists annually are for restorative care. Slight decreases in the average proportion of restorative services per treatment day occurred just prior to and immediately after introduction of dental therapists to the clinics but returned to previous levels in recent years.

An analysis by types of procedures performed by dentists in 2009-10 revealed that 38.1% were diagnostic services, 32.2% were restorative, 11.3% were preventive, and the remainder were specialty services. In 2018-19, 7 years after introduction of dental therapy to the clinical team, the average daily proportion of dental procedures by type showed that 43.9% were diagnostic, 33.8% were restorative, and 8.2% were preventive with the remainder classified as specialty services.

Dentists and dental therapists/advanced dental therapists commonly provide restorative services. In 2018-19, on average, 33.8% of dentists' services, 28.9% of advanced dental therapists' services, and 14.2% of dental therapists' services were restorative procedures. On average, more than half (57.4%) of annual fees for services by advanced dental therapists, 49.9% of annual fees from services by dentists, and 34.7% of annual fees from dental therapists' services were for restorative procedures.

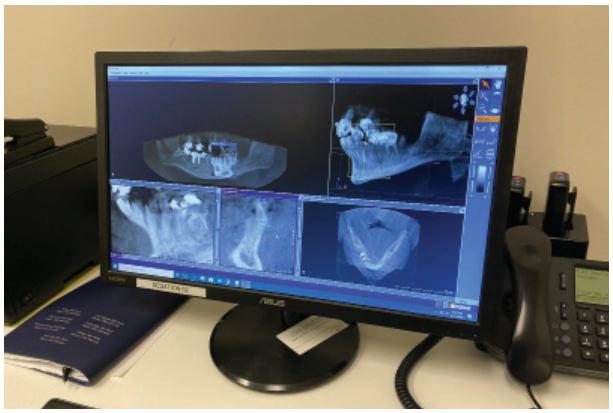
One indicator of change to daily practice is that the relative value of dental services increased on average during the years when dental therapists were on the clinical team. In 2009-10, average daily RVU production for dentists was 51.56, 43.0% of which were from restorative services. In 2018-19, average daily RVU production for dentists was 60.19. While restorative procedures constituted, on average, just over one-third of the number of daily dental services, they constituted one-half of daily RVUs (50.5%) produced by dental providers. Prosthodontic procedures represented 18.6% of average daily RVUs produced by dentists but only 3.4% of average daily procedures. In 2018-19, average daily RVUs for advanced dental therapists were 42.96, of which, more than one-half (57.8%) were for restorative services.

Other data points inform the finding of increased production after introduction of dental therapy to the clinical teams. The average daily number of procedures by dentists during the period increased from 21.69 in 2009-10 to 25.61 in 2018-19. Additionally, in 2009-10, dentists in the 2 centers completed, on average, 10.9 patient visits per treatment day; that number increased to 13.8 in 2018-19. For an organization with a mission to provide preventive and primary dental care for underserved populations and a need for efficient available capacity to meet patient demand, the results from this study provide a potentially meaningful reason to add dental therapists to the clinical team.

While extensive analysis and comparison of preventive services provided by dental therapists or advanced dental therapists with those provided by dental hygienists was not conducted for this study, it is apparent from these data that many preventive services are being provided by dentists, advanced dental therapists, and especially by dental therapists. There are several possible explanations for this trend including that many therapists in Minnesota are also dental hygienists. Another is that the number of patients who are children has noticeably increased at the dental centers. In the most recent year, 35.8% of dentists' visits, 48.3% of all dental therapist visits, and 63.4% of all advanced dental therapist visits were for children under 18 years of age, an age cohort in which prevention is emphasized. These changes may also be indicative of the general paradigm shift in dentistry away from diagnosis and treatment to prevention and early intervention in oral disease processes. A study of the impacts of dental therapy practice on the workload of dental hygienists and provision of preventive services was beyond the scope of this research but is a topic for future study.

The findings from this research suggest that one of the most immediate impacts of new workforce with dual

competencies is to supply flexible capacity to treat increasing patient caseloads. Beazoglou and co-authors conducted a study in Colorado to understand how the addition of expanded function allied personnel affected dental practices.[3] The authors found that effective use of workforce had the potential to substantially increase both capacity and productivity of a dental practice. The example of Apple Tree Dental further supports this finding.



It is not possible to determine that the beneficial outcomes at Apple Tree Dental are attributable only to adding dental therapy practice to the workforce or that these findings are generalizable. During the extended period included in this study, many environmental changes occurred which cannot be fully evaluated. The Medicaid program in the state adjusted the adult dental benefit on numerous occasions affecting both service mix and patient choice. However, it seems unlikely given the public insurance environment and low reimbursement rates that outcomes such as increased capacity to provide services, higher average intensity of services, increased numbers of procedures would not be due, at least in part, to the addition of workforce with bridging competencies.

Apple Tree Dental is positioned in the delivery system as a non-profit community dental organization providing services in the oral health safety net. Demand for services is growing as evidenced by increases in the number of patients seeking services in the dental centers annually. The organization has integrated dental therapy into practice over the 7 years since it was introduced to the state and has benefitted from the workforce in capacity and flexibility to provide oral health services to meet increasing demand from the patient population.

TECHNICAL REPORT

BACKGROUND

Equitable access to oral health services was a benchmark goal set by the Surgeon General at the turn of the 21st century. However, 2 decades since this call to action, access to oral health services eludes many. The barriers to achievement are grounded in the complexities of geography, issues of cultural, ethnic, and racial diversity, and in economic conditions affecting the delivery system and individuals seeking care.

Oral health stakeholders in Minnesota were attentive to the unmet oral health needs of a significant proportion of the state's population when in 2008 they introduced legislation to enable a new type of oral health professional intended to bridge gaps in care. The original bill recommended the creation of an oral health practitioner, a primary care dental professional trained to provide preventive and basic restorative services. The main purpose of this workforce was to act as a point of entry to the oral health care system for historically underserved populations in the state, defined as low-income populations, the Medicaid insured, residents of dental health professional shortage areas (DHPSAs), special needs populations and others with compromising medical conditions. The original bill was diverted by the legislature to a coalition of oral health stakeholders for study, revision, and reconciliation. The eventual outcome differed from the original version of the proposed bill but the substance and intent remained. In 2009, the legislature, with support from diverse and divergent stakeholders, passed a bill creating a new workforce to be trained and licensed as dental therapists with 2 different levels of dental supervision.

Dental therapists had been part of the oral health workforce internationally for many decades but no state in the US had yet permitted this workforce model to deliver clinical services. Dental therapists were mainly used in other countries to provide basic restorative services to children, but their deployment varied by country. The US Indian Health Service (IHS) in Alaska successfully trained and deployed dental health aide therapists (DHATs), a competency based dental therapy workforce model, to indigenous communities beginning in 2003. However, DHATs were not yet employed in the IHS system in the continental US in 2009. The Minnesota legislation did not limit dental therapists to treating children but required that at least one-half of patients served by dental therapists be low income or Medicaid insured, live in DHPSAs or have a chronic medical condition or disability.

The coalition that delivered the revised legislation to the state comprised a broad range of stakeholders, including dental and dental hygiene educators, who eventually built the foundational educational programs for the workforce. The University of Minnesota Dental School offered a 4-year curriculum culminating in a bachelor's degree that trained dental therapists who would ultimately work under the direct/indirect supervision of a dentist. Normandale Community College and Metropolitan State University offered a similar curriculum at a master's degree level to licensed dental hygienists with a bachelor's degree. The program prepared advanced dental therapists who, after 2,000 hours of supervised practice and competency evaluation, would be allowed to practice under general supervision at a distance from a dentist. In addition, advanced dental therapists were able to provide more services, including treatment

plan formulation and non-surgical extractions, than those qualified as dental therapists. Since 2011, the workforce model has converged such that in 2016, the dental school program began awarding a dual degree, Bachelor of Dental Hygiene/Master of Dental Therapy, so that all dental therapy graduates can now qualify for advanced dental therapy practice. A graduate degree is a legislative prerequisite for advanced dental therapy practice.

Apple Tree Dental

Apple Tree Dental is a large non-profit community dental provider that began operation in 1985 as a mobile dental program serving the elderly in and around Minneapolis and St. Paul, Minnesota. The organizational mission focuses on oral health for all by removing barriers to care; as a result, the provider has grown substantially during its 35-year history. Apple Tree Dental now operates seven centers for dental health (centers) in urban and rural areas throughout the state. The organization continues to support a substantial mobile dental program providing dental services in 145 locations in Minnesota including skilled nursing facilities, elder care centers, Head Start programs, group homes, and day habilitation programs. Patients at Apple Tree Dental comprise all age groups, many of whom have special health care needs, and the majority of whom are low-income and Medicaid eligible. The organization employs more than 200 clinical and administrative staff in the various dental centers or in the mobile dental programs. Apple Tree Dental was among the first employers of dental therapists in late 2011 and early 2012, when the first dental therapy students completed didactic and clinical education, competency evaluation, and licensure. Currently, Apple Tree Dental employs 34 dentists, 10 dental therapists/advanced dental therapists and 30 dental hygienists, including 4 serving in administrative roles.

Almost a decade since the first dental therapists in the continental US entered practice, interest exists in understanding how the dental therapy workforce has affected access to oral health services and oral health outcomes for patients as well as the impact of the workforce on practice configurations, team productivity and practice efficiency. This study examined the subset of dental therapists/advanced dental therapists in Minnesota working at Apple Tree Dental's centers between 2012 and 2019 to describe the services provided by the dentists and the dental therapists/advanced dental therapists at these centers. The analyses also compared the distribution of workflow before and after the introduction of therapists to dental teams at the organization.

Apple Tree Dental has consistently collected organizational data describing clinical services provided to patients, the providers rendering those services, and the characteristics of the patients in their care. The extensive electronic dental record includes not only the usual encounter data but also a range of patient demographic, diagnostic, and medical information. Apple Tree Dental agreed to allow a research team from the Center for Health Workforce Studies at the University of Albany, School of Public Health to analyze this data to evaluate services provided.

Minnesota Medicaid Coverage for Oral Health Services

It is important to understand the economic context into which the new workforce model was introduced. The Minnesota legislature required that dental therapists serve primarily low income and/or Medicaid insured people, populations living in DHPSAs, or those with health or developmental conditions that affected their ability to access oral health services. At the time of the dental therapy legislation, eligibility for Medicaid in Minnesota required that household income not exceed 138% of the federal poverty level (FPL). Parents with dependent children were eligible for the benefit if household income did not exceed 100% FPL and single adults with incomes up to 75% FPL also qualified. In 2013, under provisions of the Affordable Care Act (ACA), Minnesota expanded eligibility for Medicaid through the existing Minnesota Care program by offering coverage with a small premium requirement for those with household incomes up to 200% FPL and to infants, children, or pregnant women under higher income limits. The Medicaid program included dental benefits for children and for adults.

In 2009 prior to Medicaid expansion, the Minnesota state legislature significantly cut the existing comprehensive adult dental benefit in Medicaid beginning in 2010. The limits included reductions in the scope of benefits for non-pregnant adults, exclusion of certain procedures, and limits on conditions for reimbursement. For example, treatment of periodontal disease was eliminated, and the frequencies for a comprehensive dental examination or full mouth debridement were increased to once every 5 years. Fee schedules were also altered to reduce state expenditures.

While there has been some restoration of benefits in ensuing years the scope of benefits remains more limited than in the past and reimbursement for covered services remains low in comparison to neighboring states and national averages. Minnesota's Medicaid program operates a critical access dental program for qualified providers that offers an enhanced rate for dental services if the provider meets threshold criteria related to the number of Medicaid eligible people served. The majority of Medicaid eligible patients are enrolled with managed care organizations whose rates and add-on payments have varied across time, providers, and regions,[5] Approximately 80% of patients at Apple Tree Dental are low income or Medicaid eligible suggesting that state Medicaid policy has a significant impact on patients, providers, and administrative operations. While this study did not examine the effects of benefit changes and fee fluctuations on services provided to patients during the 10-year time span for this study, it is important to understand that operational income at Apple Tree Dental is largely from public insurance programs so maximizing capacity and resources to provide patient care is essential.

METHODS

This study examines encounter data that include more than a quarter of a million encounters for 76,342 patients obtaining care in one of the 7 dental centers operated by Apple Tree Dental in Minnesota. The data represented patient encounters starting February 9, 2009 until July 31, 2019. Data from Apple Tree's mobile program were excluded from this analysis. The data include the date of service, the services ren-

dered, the profession of the clinical provider, and the characteristics of the patients (ie, demographics and insurance) for each of the encounters examined. Over the study period, 15 dental therapists worked for the organization along with dentists and dental hygienists. Ten of these dental therapists also held licensure as dental hygienists; 5 did not. There are currently 10 dental therapists/advanced dental therapists in active practice at Apple Tree Dental.

Selection of Dental Centers for Detailed Analysis

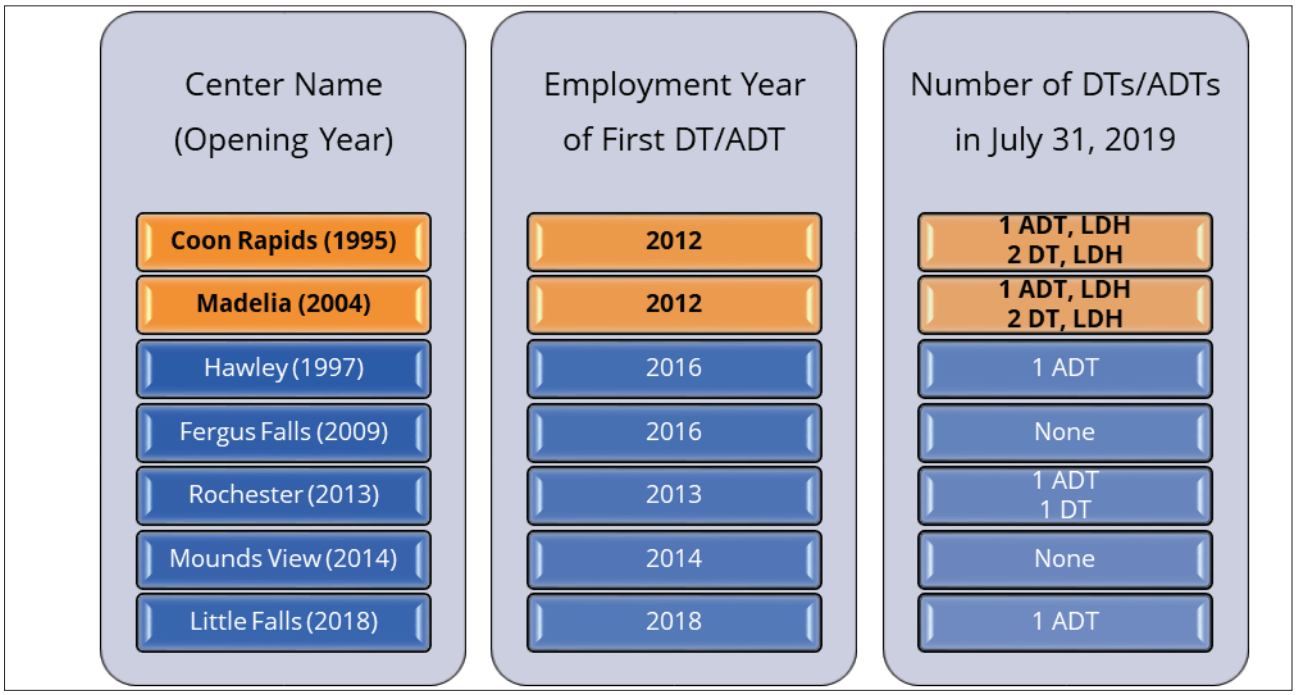
Apple Tree Dental supplied researchers with more than 10 years of data describing patient encounters and clinical activities in the seven fixed centers of the organization located in Coon Rapids, Fergus Falls, Hawley, Little Falls, Madelia, Mounds View, and Rochester, Minnesota over the period. Data describing the many clinical services provided through the extensive mobile dental program at 145 locations in the state was excluded due to the complexity of tracking workforce contributions at the varying locations over many years.

Research staff determined that ultimate outcomes from inclusion of dental therapists on a clinical dental staff would best be demonstrated by using data only from centers with continuous experience with dental therapists. Staff reasoned that integration of new workforce requires a learning curve for patients and professional staff and that impacts of this integration would be apparent only over time as dental therapy became routine practice

Two of the dental centers at Apple Tree had used dental therapists during the period of interest but experienced gaps during which dental therapists were not part of the staffing configurations in those centers. Three centers only more recently employed dental therapists (2016-2018), so there was insufficient post-employment data to effect the desired pre- and post-dental therapy comparisons (see Figure 1 for employment time line).

Two of the 7 centers had continuous and uninterrupted experience with a dental therapist on staff and were, therefore, selected for the more extensive analysis. These centers were located at Coon Rapids (first dental therapist hired 02/06/2012) which serves an urban/metropolitan population and Madelia (first dental therapist hired 02/06/2012, which serves patients in a rural area in Minnesota. These were the first 2 centers to engage dental therapists at Apple Tree Dental. Each had 3 years of clinical operations data prior to employing a dental therapist and each had continuously used one or more dental therapists to provide services beginning in 2012.

FIGURE 1. Employment Time Line of Dental Therapists and Advanced Dental Therapists in the Dental Centers at Apple Tree Dental



Apple Tree Dental Encounter Data

The encounter data supplied by Apple Tree Dental began on February 9, 2009 (3 years prior to the first employment of a dental therapist at the organization) and ended on July 31, 2019, a date agreed upon in the study contract.

Various statistical data analyses (ie, frequency, percentage, t-test, chi-square test, and trend estimates using linear regression) were used to compare the quantity and type of services performed by dentists before and after introduction of dental therapists/advanced dental therapists to the clinical teams at the 2 centers. Descriptive statistical data analyses were also employed to compare quantity and type of services performed by dentists and dental therapists/advanced dental therapists after their introduction to practice. Dental services were organized into categories based on procedure code groupings in current dental terminology. Those categories are adjunctive, diagnostic, preventive, restorative, oral and maxillofacial surgery, endodontic, periodontic, orthodontic, prosthetics (maxillofacial) and implant, and prosthodontic (removable) services.

The Use of Relative Value Units

One intended component of the study was an analysis of data to understand changes over time in the contributions of various oral health professionals to patient care. The quantity of patients and their multiple encounters, the dynamic number of providers, and the large number of dental services provided since the introduction of dental therapy to the organization created a challenge to standardizing the data for

comparative analysis and to achieving a clear understanding of the contributions of the various workforce to patient care.

In medicine, services provided to patients are compensated based on a standardized rating system managed by the Center of Medicaid and Medicare called the Resource Based Relative Value Scale (RBRVS). This differential scale consists of individual numerical ratings for each of numerous medical services and procedures anchored to a service with a base value of 1.0. The relative value unit (RVU) for each type of service is a complex number that accounts for the various inputs to that service including the training, expertise and technical skill required of the provider, the time necessary to deliver the service, the difficulty of the service, the expense of providing the service including the cost of materials and medications, a malpractice factor to account for the risk related to the service or procedure and other factors. The numerical score for each service is used with financial conversion factors and geographic adjustment factors to determine the amount of compensation for each service such that more time and resource intensive services (eg, brain surgery) are valued and compensated more highly than routine services (eg, performing a blood draw). Relative value units are now commonly used in determination of physician payments by not only the federal government but also by private insurers throughout the US. Although dental services are not currently similarly rated or reimbursed, there has been ongoing discussion about the utility of RVUs as a means to differentiate and value services and determine reimbursement for dental services. The Montana Medicaid program uses RVUs to determine fees for dental services.[5] The Indian Health Service has used RVUs for dental services in its compensation metrics for several years.

In order to evaluate changes in service delivery by particular workforce (ie, dentists and dental therapists/advanced dental therapists) across a selected time period, study staff recognized that a standardized scale ranking complexity of services would be useful. Researchers identified a compendium of relative values for dental services compiled by a commercial vendor using ongoing national surveys of dentists to build the original scale and to maintain its currency over time. The dental file of RVUs, Relative Values for Dentists 2019 by Relative Value Studies, Inc., was purchased from the vendor. Applicable RVU values were assigned to each dental procedure in the Apple Tree Dental encounter data based on the current dental terminology (CDT) code that described each service. Unit values were then used in sum to determine the average daily production and intensity of services provided by dentists, dental therapists, and advanced dental therapists over time, including the 3-year period before and the 7 years after introduction of dental therapy to a dental center practice.

Impact of Service Shifts on Revenue From Services

The study also called for an evaluation of changes in practice revenue related to introduction of therapists to practice. Researchers recognized that using a standardized national fee schedule to describe financial production outcomes would be more broadly useful than state specific reimbursement data. The decision to use the national fee scale was also supported by Minnesota's Medicaid program's uniform reimburse-

ment across dental provider types. Thus, a standardized fee could be applied whether the services were provided by a dentist, dental therapist, or dental hygienist.

The Survey of Dental Fees conducted periodically by the American Dental Association, solicits a sample of general and specialty dentists to describe their standard fees for common dental procedures. The ADA uses the data obtained from the survey to compile an average national fee scale as well as 9 average regional fee scales based on US Census Bureau Regions in the US. These scales provide average self-reported fees by procedure as reported by general practitioners and each of the 6 dental specialties for 269 commonly performed dental procedures. The standardized fees described in the Survey of Dental Fees 2018[1] were consistently applied to the dental procedures in the Apple Tree Dental database based on the CDTs in the files. Applying the 2018 fees to all years since 2009 also permitted for inflation adjustment to actual fees generated in earlier years.

Reporting Metrics

The data presented in this report used treatment days as the denominator in many of the equations used to describe the contributions of the various oral health professionals to patient care. While staffing at the various centers depends largely on staff permanently located at each center, the breadth and depth of the organization allows substitution by other providers in the absence of one or another type of provider. As a result, the actual number of providers in a year in each dental center exceeded the number of clinical positions for that type of professional. These substitutions created a problem in accounting for staff since some provided coverage for a day, a month, or more. In addition, we were unable to exactly identify the full-time/part-time contributions to patient care. Thus, researchers determined that treatment days would be used to adjust for full-time/part time staff participation and to adjust for substitutions in staff. If a clinical provider completed any patient service in the dental center of interest on a day, that treatment day was included in the daily, monthly, and annual total of treatment days for that center.

Minnesota's Dental Therapist Workforce Data

To provide a description of the dental therapy workforce, researchers compared the characteristics (demographics, education, and practice) of all dental therapists/advanced dental therapists working in Minnesota with the dental therapists/advanced dental therapists working at Apple Tree Dental in 2018. Data for this comparison were extracted from a survey of the statewide dental therapy workforce conducted by the Office of Rural Health and Primary Care of the Minnesota Department of Health. According to the Minnesota Board of Dentistry, there were 92 dental therapists (including advanced dental therapists) with active licenses as of December 2018. The survey focused on all dental therapists with a license in 2018 and had a 66% response rate. The department supplied summary statistics for all dental therapists in the state as well as data describing the subset of therapists at Apple Tree Dental in 2018. The descriptive analysis of dental therapists and those at Apple Tree Dental is located in Appendix A of this technical report.

Characteristics of the Patient Population at Apple Tree Dental

Appendix B includes tables describing the patient population at Apple Tree Dental during the period of interest to this study. The tables describe patients' characteristics including age (children under the age of 18, working adults aged 18 to 64, and adults aged 65 years or older) and insurance type (commercial, Medicaid, self-pay, PPO, and veterans).

FINDINGS

Services Provided by Dentists, Dental Therapists, and Advanced Dental Therapists

The following tables and graphs describe production volume, the intensity mix of procedures, and the fees generated from services by dentists, dental therapists, and advanced dental therapists over the 10-year study period by type of dental procedure.

Production Measured by Numbers of Procedures by Dentists

Dentists' production by number of services/procedures was calculated per treatment day for the 3 years before and the 7 years after dental therapists joined the clinical teams. The average number of procedures performed by a dentist per treatment day decreased after introduction of dental therapists and advanced dental therapists to the clinics from an average of 21.69 procedures per day in 2009-10 to 19.84 in 2014-15 but gradually increased to 25.61 in 2018-19 (Table 1). Over the 10-year period, the absolute number of procedures varied in all categories of service due in part to the variation in number of treatment days per year. The most common procedures in all years were diagnostic or restorative services.

TABLE 1. Total Number of Procedures by Dentists by Type of Procedure, by Year, and Average Number of Procedures Produced by Dentist per Treatment Day, 2009-19

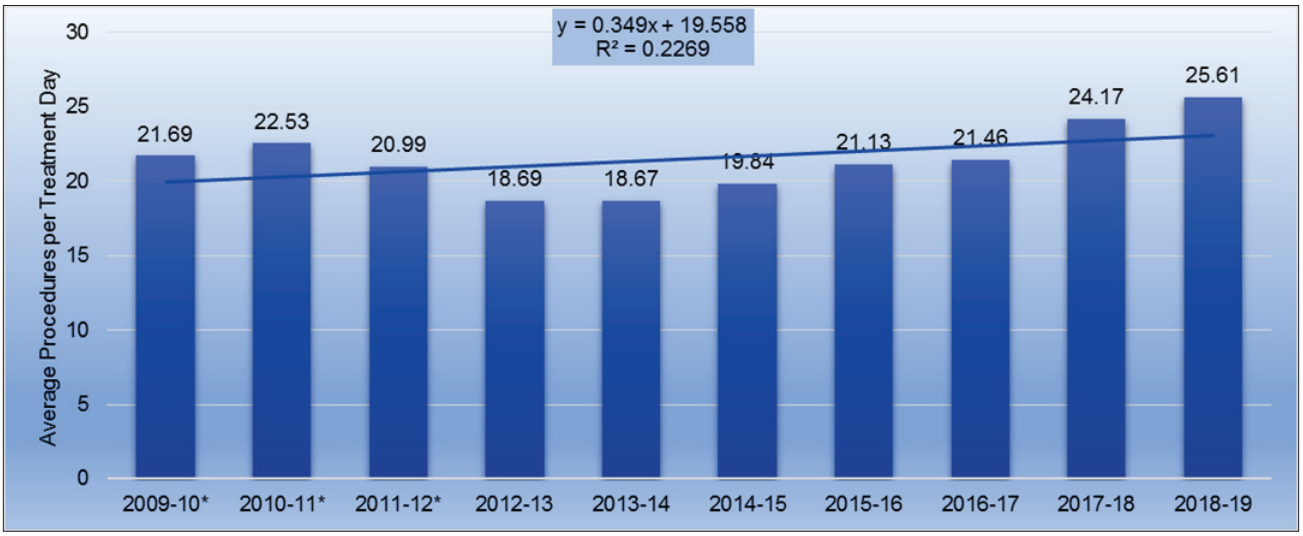
Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	10,273	13,532	13,308	12,269	12,742	11,921	10,962	11,385	11,818	11,046
Preventive	3,055	4,717	3,876	1,904	998	1,108	1,224	1,955	2,140	2,055
Restorative	8,667	10,051	9,379	9,010	8,800	8,696	9,053	8,882	9,545	8,517
Endodontics	481	380	311	351	420	422	336	343	577	541
Periodontics	44	24	35	45	54	37	43	11	8	2
Prosthodontics	2,057	2,043	1,462	811	1,179	1,213	1,310	882	1,017	866
Prosthetics and Implant	46	71	87	100	137	137	158	34	0	21
Oral and Maxillofacial Surgery	1,696	2,268	2,748	3,714	3,945	4,097	4,489	2,314	2,032	1,376
Orthodontics	0	3	7	0	0	4	0	0	3	1
Adjunctive	626	509	900	1,265	2,283	2,356	2,702	1,467	731	754
Total Annual Procedures	26,945	33,598	32,113	29,469	30,558	29,991	30,277	27,273	27,871	25,179
# Treatment Days	1,242	1,491	1,530	1,577	1,637	1,512	1,433	1,271	1,153	983
Average Procedures/ Treatment Day	21.69	22.53	20.99	18.69	18.67	19.84	21.13	21.46	24.17	25.61

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The positive trend in average number of procedures produced by dentists per treatment day was not statistically significant (*P*=0.164) (Figure 2). A decrease in average number of procedures per treatment day 3 years immediately after introduction of dental therapists to the clinical teams reversed in 2015-16. In 2016-17, dentists' production was similar to that of pre-dental therapy years. The average number of procedures per treatment day has risen since 2017 to a high of 25.61 procedures in 2018-19. The positive 10-year trend in average number of procedures produced by a dentist per treatment day was not statistically significant (*P*=0.16439). However, the increasing trend in the average number of procedures per treatment day by a dentist after introduction of dental therapists to the clinical teams was statistically significant (*P*<0.001).

FIGURE 2. Trends in Average Number of Procedures by Dentist per Treatment Day, 2009-19



* Represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental 2009-19.

The distribution by type of dental procedure varied as a percentage of the total procedures performed in an average treatment day (Table 2). The proportion of an average workday given to restorative procedures began to diminish in the 2 years prior to and the 3 years immediately following introduction of dental therapy from 32.2% in 2009-10 to 29.0% in 2015-16. The proportional contribution of restorative services to production returned to pre-dental therapy levels beginning in 2016-17. In 2018-19, restorative procedures represented, on average, 33.8% of procedures performed per treatment day. Diagnostic procedures represented, on average, 38.1% of daily procedures by dentists in 2009-10; in 2018-19, they represented 43.9%. The proportion of daily procedures that were preventive decreased from 11.3% in 2009-10 to 3.7% in 2014-15 rising to 8.2% in 2018-19. The proportion of daily procedures classified as oral and maxillofacial surgery increased after introduction of dental therapists from 6.3% in 2009-10 to 14.8% in 2015-16, but dropped to 5.5% of daily procedures in 2018-19. The IV sedation/implant dentistry program originally housed at Coon Rapids relocated in a planned move to the nearby Mounds View Dental Center beginning in 2016-17 resulting in a decline in the number of implant and oral surgery services at the Coon Rapids center. Changes in the proportion of procedures performed by a dentist per treatment day over the 10- year period were not statistically significant except for the positive trend in prosthodontic procedures (P=0.022) and the negative trend in periodontic procedures (P=0.044).

TABLE 2. Procedure Type as a Proportion of All Procedures Performed by a Dentist per Treatment Day by Year, 2009-19

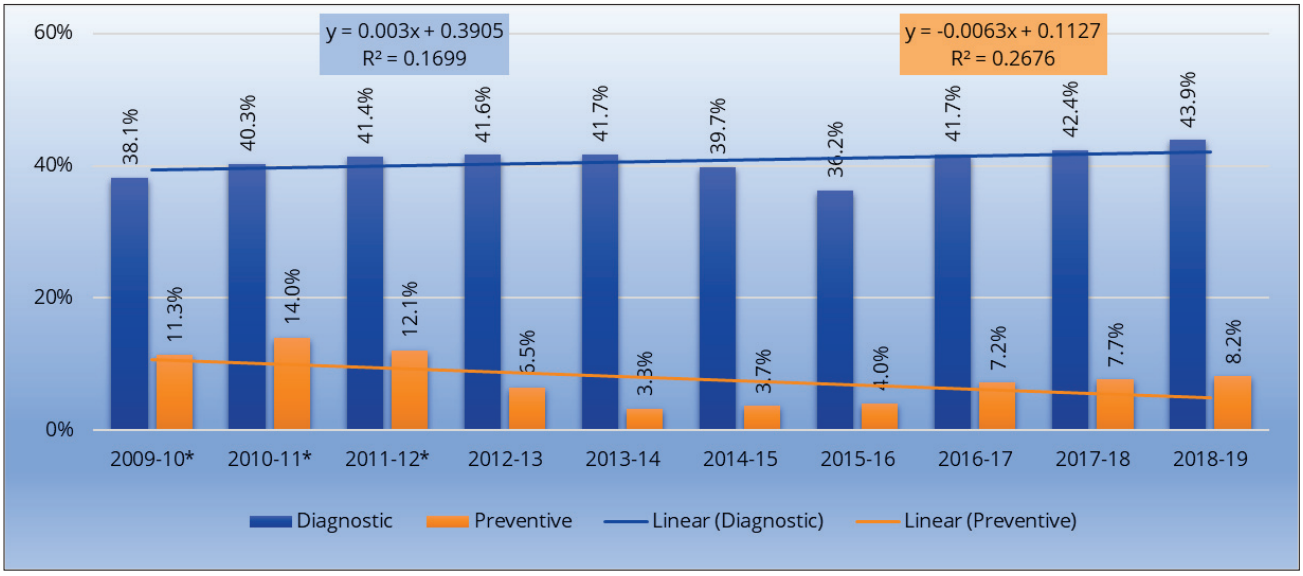
Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	38.1%	40.3%	41.4%	41.6%	41.7%	39.7%	36.2%	41.7%	42.4%	43.9%
Preventive	11.3%	14.0%	12.1%	6.5%	3.3%	3.7%	4.0%	7.2%	7.7%	8.2%
Restorative	32.2%	29.9%	29.2%	30.6%	28.8%	29.0%	29.9%	32.6%	34.2%	33.8%
Endodontics	1.8%	1.1%	1.0%	1.2%	1.4%	1.4%	1.1%	1.3%	2.1%	2.1%
Periodontics	0.2%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%
Prosthodontics	7.6%	6.1%	4.6%	2.8%	3.9%	4.0%	4.3%	3.2%	3.6%	3.4%
Prosthetics and implant	0.2%	0.2%	0.3%	0.3%	0.4%	0.5%	0.5%	0.1%	0.0%	0.1%
Oral and maxillofacial surgery	6.3%	6.8%	8.6%	12.6%	12.9%	13.7%	14.8%	8.5%	7.3%	5.5%
Orthodontics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Adjunctive	2.3%	1.5%	2.8%	4.3%	7.5%	7.9%	8.9%	5.4%	2.6%	3.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Changes in the proportion of procedures performed by a dentist per treatment day were not significant for diagnostic (*P*=0.237) procedures (a positive trend) or for preventive (*P*=0.126) procedures (a negative trend) in the 10-year period (Figure 3).

FIGURE 3. Trends in Average Daily Proportion of Diagnostic and Preventive Procedures Performed by a Dentist per Treatment Day by Year, 2009-2019

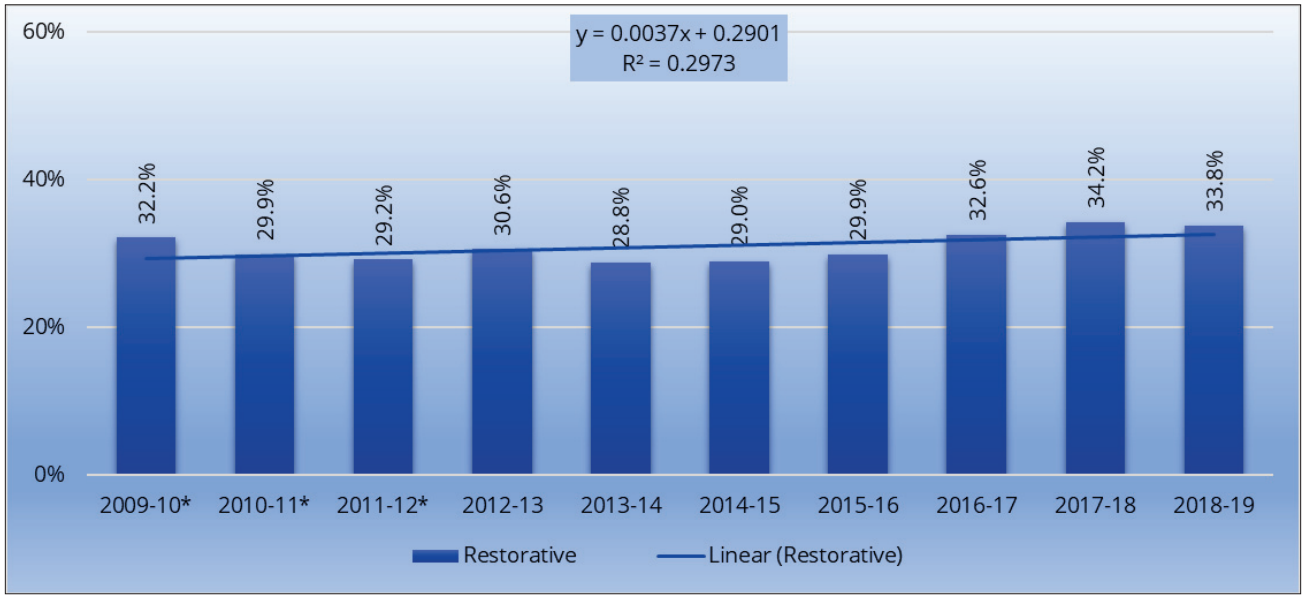


* Represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The 10-year trend in average daily proportion of restorative procedures performed by a dentist during the study period was not statistically significant (*P*=0.103) (Figure 4).

FIGURE 4. Trend in Average Daily Proportion of Restorative Procedures Performed by a Dentist per Treatment Day by Year, 2009-2019

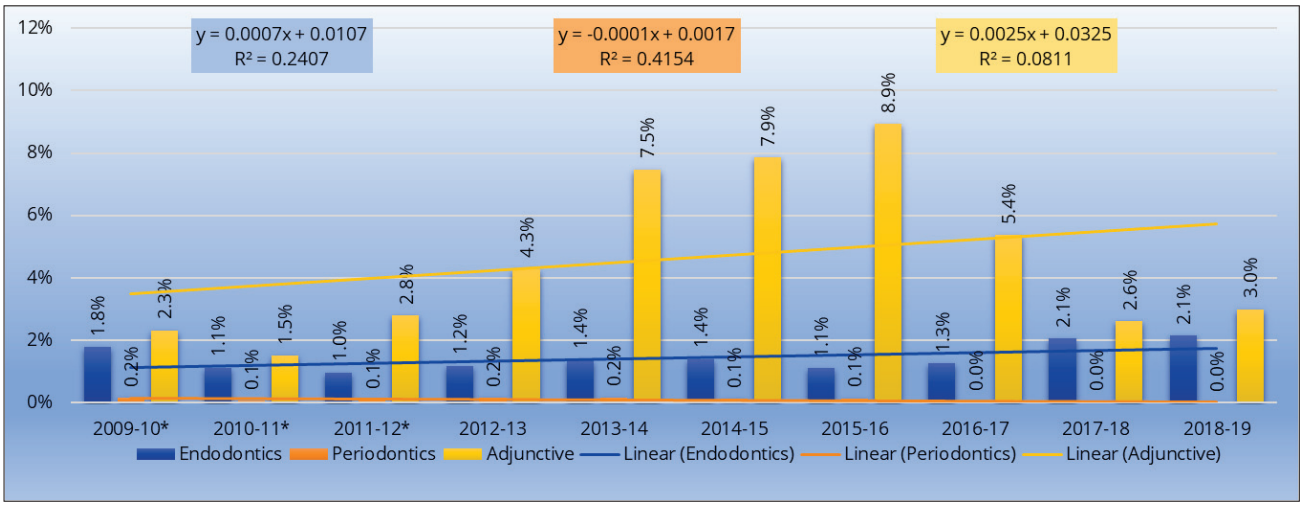


* Represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The 10-year trends in average daily proportion of procedures performed by a dentist indicated a positive trend for endodontic procedures (*P*=0.150) and a positive trend in adjunctive procedures (*P*=0.425); however, neither was statistically significant. A negative trend for periodontic procedures (*P*=0.044) was statistically significant (Figure 5).

FIGURE 5. Trends in Average Daily Proportion of Endodontic, Periodontic, and Adjunctive Procedures Performed by a Dentist per Treatment Day by Year, 2009-2019

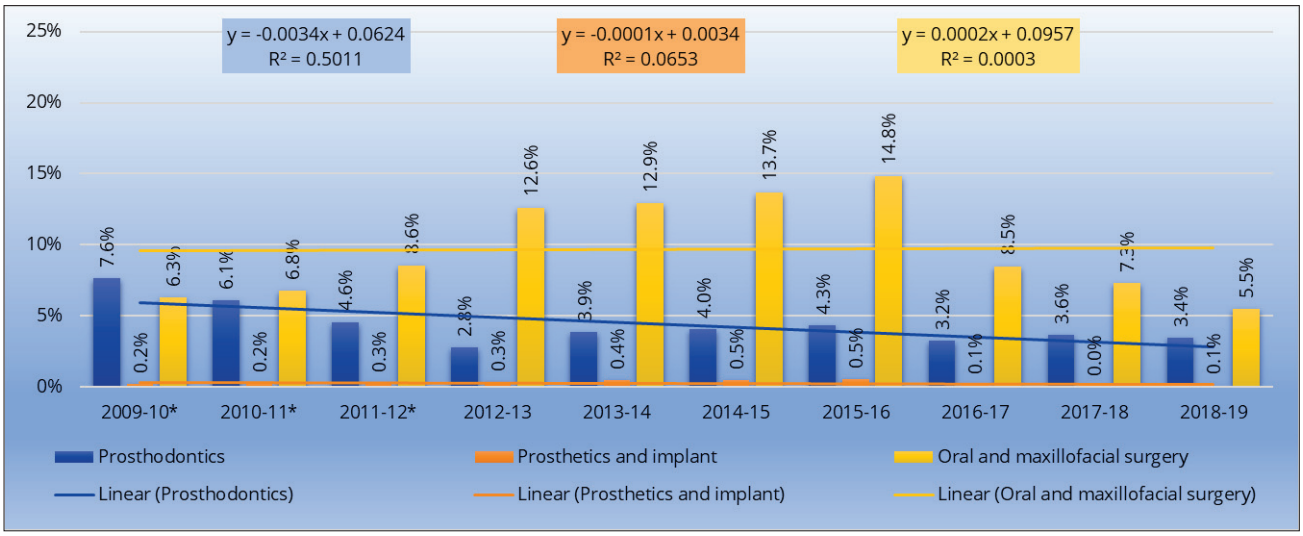


* Represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The negative 10-year trend in the average daily proportion of prosthodontic procedures (*P*=0.022) performed by a dentist was statistically significant while the negative trend in prosthetics and implants (*P*=0.476) was not. The trend in oral and maxillofacial surgery services was also not significant (*P*=0.961) (Figure 6).

FIGURE 6. Trends in Average Daily Proportion of Prosthodontic, Prosthetic and Implant, and Oral and Maxillofacial Surgery Procedures Performed by a Dentist per Treatment Day by Year, 2009-2019



* Represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Production Generated by Dentists Described by Relative Value Units (RVUs)

Dentists' production values (measured in RVUs) showed an increase in service intensity over the 10-year period with an average of 51.56 RVUs produced per dentist treatment day in 2009-10 progressing to an average of 60.19 RVUs per treatment day in 2018-2019 (Table 3). In the 3-year period prior to the introduction of dental therapists (2009 to 2012), average RVUs per treatment day were 51.56, 48.20, and 46.42, respectively. In most years after introduction of dental therapists, the RVUs produced by a dentist per treatment day met or exceeded those generated in the pre-dental therapy years. In 2016-17 RVUs for dentists were lower than in the previous or subsequent year due to several staffing changes including a dentist's departure, and relocation of dentists to other dental centers, including one who performed IV sedation and complex procedures.

TABLE 3. Total Number of Dental Relative Value Units (RVUs) produced by Dentists by Type of Procedure, by Year, and Average Number of RVUs Produced by Dentist per Treatment Day, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	8,110.75	10,233.15	10,446.20	10,041.00	10,278.90	9,764.05	8,849.15	9,029.80	9,348.85	8,745.20
Preventive	2,480.70	3,572.00	2,700.20	1,599.80	945.70	1,001.90	1,128.60	1,683.20	1,824.80	1,739.80
Restorative	27,509.60	30,404.20	29,673.30	30,164.20	29,330.80	29,722.90	30,500.10	30,397.40	33,272.50	29,865.40
Endodontics	4,424.75	3,328.65	2,680.80	3,335.70	3,071.40	2,842.60	2,571.10	2,179.40	3,200.80	2,635.40
Periodontics	246.40	174.20	196.80	174.10	251.80	202.30	190.70	45.50	34.20	9.30
Prosthodontics	13,891.10	15,301.30	12,939.30	15,144.40	18,002.30	16,343.90	17,044.40	10,566.00	12,338.40	10,997.50
Prosthetics and implant	934.40	1,420.00	2,253.90	2,180.90	2,876.00	2,971.60	3,449.50	492.10	0.00	364.10
Oral and maxillofacial surgery	4,507.30	6,290.50	8,746.50	12,020.40	12,632.70	13,372.30	15,500.00	6,561.30	5,461.80	3,808.60
Orthodontics	0.00	50.80	53.80	0.00	0.00	0.00	0.00	0.00	3.40	3.40
Adjunctive	1,932.10	1,094.70	1,331.65	1,648.00	2,127.15	2,007.85	2,654.10	2,623.75	1,050.65	997.65
Total Annual RVUs	64,037.10	71,869.50	71,022.45	76,308.50	79,516.75	78,229.40	81,887.65	63,578.45	66,535.40	59,166.35
# Treatment Days	1,242	1,491	1,530	1,577	1,637	1,512	1,433	1,271	1,153	983
Average RVUs/ Treatment Day	51.56	48.20	46.42	48.39	48.57	51.74	57.14	50.02	57.71	60.19

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Restorative services constituted the highest proportion of average RVUs per dentist treatment day in every year examined for this study (43.0% in 2009-10; 50.5% in 2018-19) followed by prosthodontic services (21.7% in 2009-10; 18.2% in 2018-19) (Table 4).

TABLE 4. Proportion of RVUs Generated per Dentist Treatment Day by Procedure Type and Year, 2009-19

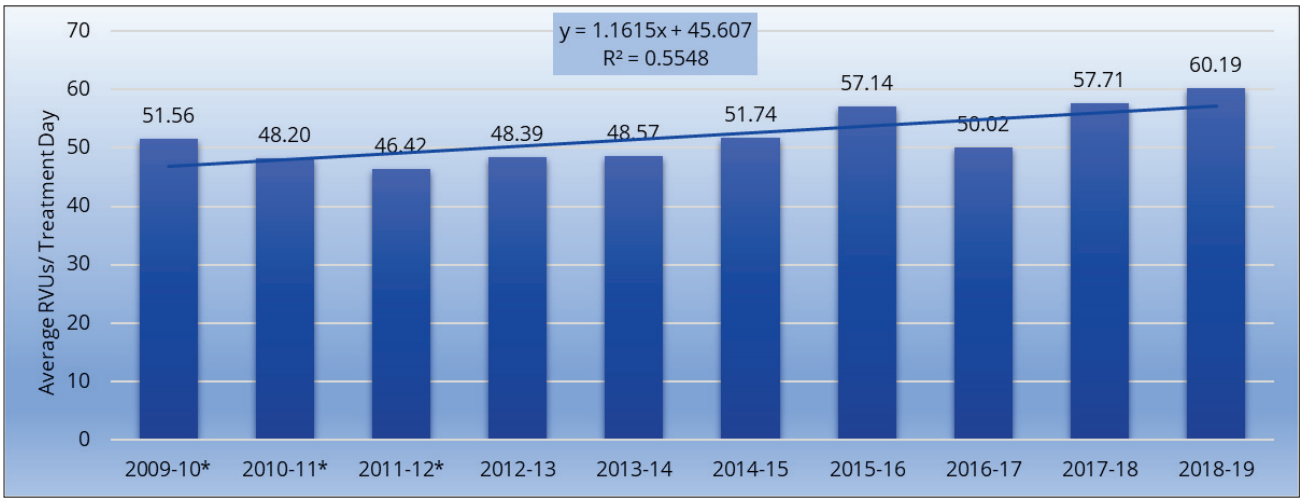
Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	12.7%	14.2%	14.7%	13.2%	12.9%	12.5%	10.8%	14.2%	14.1%	14.8%
Preventive	3.9%	5.0%	3.8%	2.1%	1.2%	1.3%	1.4%	2.6%	2.7%	2.9%
Restorative	43.0%	42.3%	41.8%	39.5%	36.9%	38.0%	37.2%	47.8%	50.0%	50.5%
Endodontics	6.9%	4.6%	3.8%	4.4%	3.9%	3.6%	3.1%	3.4%	4.8%	4.5%
Periodontics	0.4%	0.2%	0.3%	0.2%	0.3%	0.3%	0.2%	0.1%	0.1%	0.0%
Prosthodontics	21.7%	21.3%	18.2%	19.8%	22.6%	20.9%	20.8%	16.6%	18.5%	18.6%
Prosthetics and implant	1.5%	2.0%	3.2%	2.9%	3.6%	3.8%	4.2%	0.8%	0.0%	0.6%
Oral and maxillofacial surgery	7.0%	8.8%	12.3%	15.8%	15.9%	17.1%	18.9%	10.3%	8.2%	6.4%
Orthodontics	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Adjunctive	3.0%	1.5%	1.9%	2.2%	2.7%	2.6%	3.2%	4.1%	1.6%	1.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The trend in average RVUs per dentist treatment day over the 10-year period was positive and statistically significant (*P*=0.013) (Figure 7).

FIGURE 7. Trends in Average Number of RVUs Produced by Dentist per Treatment Day, 2009-19

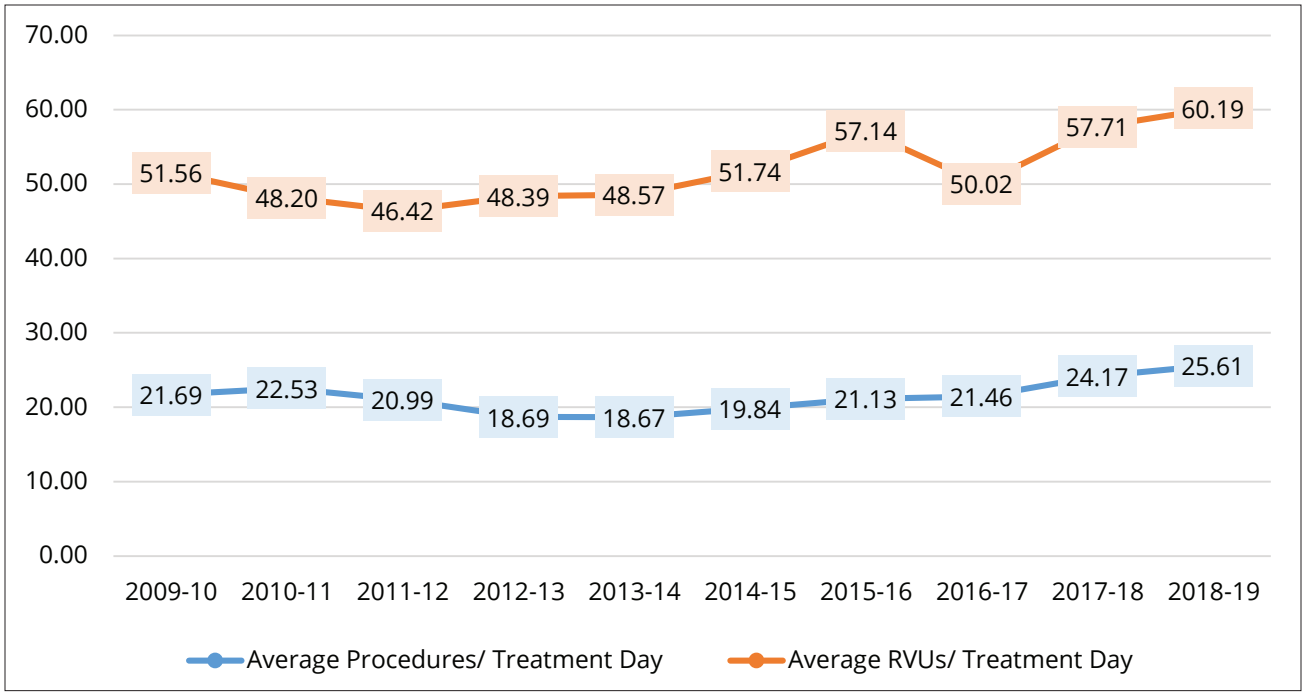


* Represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental 2009-19.

The average number of procedures performed by a dentist per treatment day increased after the introduction of dental therapists/advanced dental therapists to the centers' dental teams from 21.69 in 2009-10 to 25.61 in 2018-19 (Figure 8). Average number of procedures decreased immediately after introduction of dental therapists to the treatment teams but returned to pre-dental therapy levels in 2016-17. The average number of RVUs per treatment day has steadily increased (with the exception of 2016-17) since the advent of dental therapy in the centers. This suggests that dentists are, on average, providing not only more services, but also higher value/greater intensity services than in the past.

FIGURE 8. Ten-Year Trends in Average Number of Procedures Performed by a Dentist per Treatment Day and Average Number of Relative Value Units Produced by a Dentist per Treatment Day, 2009-19



Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Production Generated by Dentists Measured by Average Fees from Procedures

Fees for services provided by dentists increased on average per treatment day in all years (with the exception of 2016-17) since the introduction of dental therapists to the dental centers (Table 5). Average fees per treatment day increased from $3,604.52 in 2009-10 to an average of $4,194.01 per treatment day in 2018-19 (all fees stated in terms of the 2018 fee schedule to adjust for inflation). Fees from restorative, prosthodontic, and diagnostic procedures represent the majority of fees generated by dentists in 2018-19.

TABLE 5. Annual Fees Produced From Dentists' Services by Procedure Type and Average Fees per Dentist per Treatment Day, 2009-19

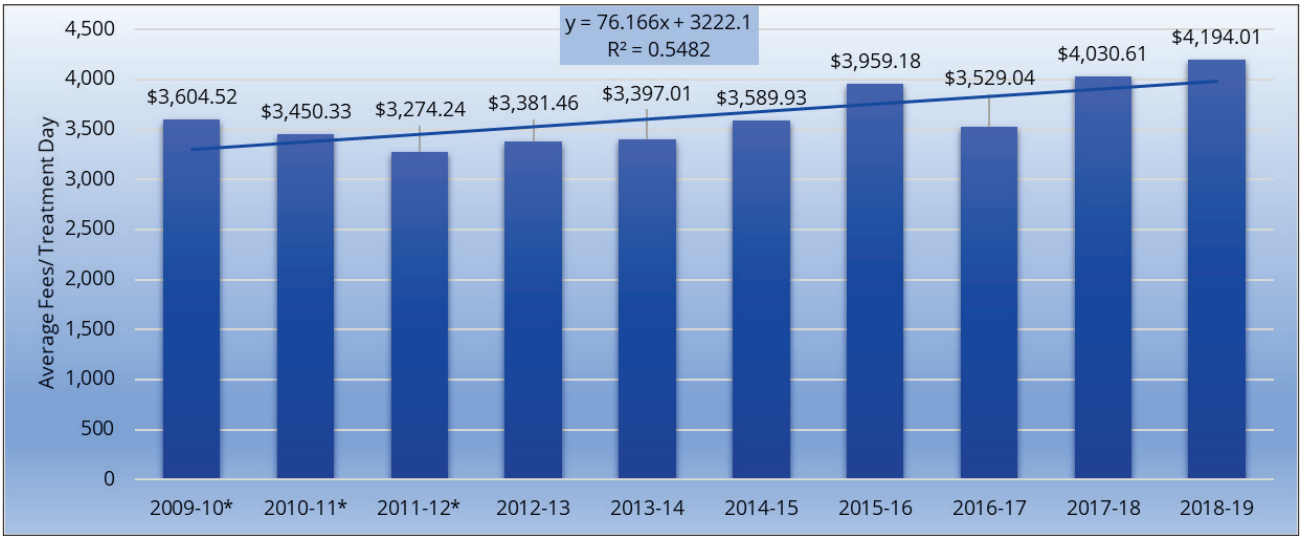
Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	$610,473.05	$781,527.84	$789,890.65	$760,952.87	$783,278.30	$749,019.31	$677,539.92	$686,843.80	$709,869.95	$667,425.02
Preventive	$171,393.91	$250,525.82	$188,819.72	$111,157.07	$65,816.50	$69,606.34	$78,436.80	$117,018.68	$129,430.46	$122,890.32
Restorative	$1,980,534.53	$2,218,752.51	$2,128,521.86	$2,135,580.65	$2,077,279.56	$2,082,157.86	$2,141,251.26	$2,125,677.20	$2,302,602.66	$2,057,361.90
Endodontics	$335,124.67	$254,437.30	$204,755.83	$255,970.66	$236,811.57	$220,330.01	$199,782.22	$167,530.93	$246,822.83	$204,852.99
Periodontics	$15,456.39	$9,853.17	$11,994.67	$10,209.64	$14,447.00	$11,759.60	$11,470.51	$2,840.74	$1,278.03	$179.74
Prosthodontics	$842,283.66	$974,063.60	$810,351.68	$933,761.61	$1,133,760.52	$996,461.74	$1,077,688.29	$653,370.67	$764,304.46	$683,557.66
Prosthetics and implant	$61,229.10	$93,186.13	$142,213.96	$137,751.55	$187,949.81	$188,822.15	$218,532.99	$32,169.89	$0.00	$23,240.02
Oral and Maxillofacial surgery	$348,444.91	$491,270.13	$651,159.18	$891,705.44	$936,438.58	$992,018.46	$1,097,379.26	$510,878.55	$427,789.06	$300,962.79
Orthodontics	$0.00	$3,247.25	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Adjunctive	$111,875.40	$67,573.53	$81,886.97	$95,470.81	$125,118.41	$117,806.01	$171,420.89	$189,076.36	$65,193.39	$62,243.97
Total Annual Fees	$4,476,815.62	$5,144,437.28	$5,009,594.52	$5,332,560.30	$5,560,900.25	$5,427,981.48	$5,673,502.14	$4,485,406.82	$4,647,290.84	$4,122,714.41
# Treatment Days	1,242	1,491	1,530	1,577	1,637	1,512	1,433	1,271	1,153	983
Average Fees/ Treatment Day	$3,604.52	$3,450.33	$3,274.24	$3,381.46	$3,397.01	$3,589.93	$3,959.18	$3,529.04	$4,030.61	$4,194.01

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The positive trend in the average fees per dentist treatment day between 2009 and 2019 was statistically significant (*P*=0.014) (Figure 9).

FIGURE 9. Trends in Average Fees per Dentist Treatment Day, 2009-2019



* Represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Almost half (49.9%) of fees generated by dentists in 2018-19 were from restorative procedures (Table 6). The data showed a slight positive trend in fees for diagnostic and restorative services and negative trends in specialty services in the most recent 3-year period (2016 to 2019). The trends in the proportions of fees by procedure type over the 10-year period were not statistically significant except for the negative trends in the proportion of fees generated by periodontic services (*P*=0.001).

TABLE 6. Percentage of Annual Fees Produced From Dentists' Services by Procedure Type, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	P-Value[b]
Diagnostic	13.6%	15.2%	15.8%	14.3%	14.1%	13.8%	11.9%	15.3%	15.3%	16.2%	0.570
Preventive	3.8%	4.9%	3.8%	2.1%	1.2%	1.3%	1.4%	2.6%	2.8%	3.0%	0.194
Restorative	44.2%	43.1%	42.5%	40.0%	37.4%	38.4%	37.7%	47.4%	49.5%	49.9%	0.198
Endodontics	7.5%	4.9%	4.1%	4.8%	4.3%	4.1%	3.5%	3.7%	5.3%	5.0%	0.228
Periodontics	0.3%	0.2%	0.2%	0.2%	0.3%	0.2%	0.2%	0.1%	0.0%	0.0%	**0.001**
Prosthodontics	18.8%	18.9%	16.2%	17.5%	20.4%	18.4%	19.0%	14.6%	16.4%	16.6%	0.185
Prosthetics and implant	1.4%	1.8%	2.8%	2.6%	3.4%	3.5%	3.9%	0.7%	0.0%	0.6%	0.308
Oral and maxillofacial surgery	7.8%	9.5%	13.0%	16.7%	16.8%	18.3%	19.3%	11.4%	9.2%	7.3%	0.951
Orthodontics	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Adjunctive	2.5%	1.3%	1.6%	1.8%	2.2%	2.2%	3.0%	4.2%	1.4%	1.5%	0.641
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	N/A

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] P-value in bold was significant.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Production Generated by Dental Therapists and Advanced Dental Therapists Measured by Numbers of Procedures

The introduction of dental therapists at Apple Tree Dental occasioned an increase in production due to greater capacity. Dental therapists gradually provided a higher number of procedures per treatment day over the study period with the exception of the years between 2014 and 2017 when there were no dental therapists in the 2 centers examined for this study; all therapists in the centers in those years held advanced certification (Table 7). The positive trend in average procedures per dental therapist treatment day was statistically significant (*P*=0.002).

TABLE 7. Total Number of Procedures by Dental Therapists by Type of Procedure, by Year, and Average Number of Procedures Produced by Dental Therapist per Treatment Day, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19
Diagnostic	-	-	-	655	287	-	-	-	1,037	2,576
Preventive	-	-	-	1,688	723	-	-	-	2,001	3,991
Restorative	-	-	-	1,878	1,102	-	-	-	1,770	1,146
Endodontics	-	-	-	11	23	-	-	-	60	28
Periodontics	-	-	-	58	17	-	-	-	53	110
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	28	21	-	-	-	101	48
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	32	38	-	-	-	114	152
Total Annual Procedures	-	-	-	4,350	2,211	-	-	-	5,136	8,051
# Treatment Days	-	-	-	304	141	-	-	-	293	416
Average Procedures/ Treatment Day	-	-	-	14.31	15.68	-	-	-	17.53	19.35

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.

[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

In 2018-19, half of all procedures provided by dental therapists in the two Apple Tree Dental centers were preventive (49.6%) (Table 8). Restorative procedures constituted 43.2% of services supplied by dental therapists in 2012-13 and 34.5% of all procedures in 2017-18. In 2018-19, 14.2% of services supplied to patients by dental therapists were restorative. Changes in the proportional distribution of procedures over the 10-year period were not statistically significant.

TABLE 8. Procedure Type as a Proportion of All Procedures Performed by a Dental Therapist by Year, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19	P-Value
Diagnostic	-	-	-	15.1%	13.0%	-	-	-	20.2%	32.0%	0.120
Preventive	-	-	-	38.8%	32.7%	-	-	-	39.0%	49.6%	0.290
Restorative	-	-	-	43.2%	49.8%	-	-	-	34.5%	14.2%	0.147
Endodontics	-	-	-	0.3%	1.0%	-	-	-	1.2%	0.3%	0.886
Periodontics	-	-	-	1.3%	0.8%	-	-	-	1.0%	1.4%	0.834
Prosthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Oral and maxillofacial surgery	-	-	-	0.6%	0.9%	-	-	-	2.0%	0.6%	0.823
Orthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Adjunctive	-	-	-	0.7%	1.7%	-	-	-	2.2%	1.9%	0.199
Total Annual Procedures	-	-	-	100.0%	100.0%	-	-	-	100.0%	100.0%	N/A

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.

[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Advanced dental therapists provided a wide range of procedures over the 6-year period after the first dental therapists were certified for advanced status in 2013-14 (Table 9). The highest average number of procedures per treatment day occurred in 2016-2017, the same year in which the average number of procedures by dentists in the 2 centers was lowest. The average number of procedures per advanced dental therapist treatment day were highest in 2016-17 (29.16), 2017-18 (26.80), and 2018-19 (27.77). The positive trend in average number of procedures per advanced dental therapist treatment day was statistically significant (*P*=0.028).

TABLE 9. Total Number of Procedures by Advanced Dental Therapists by Type of Procedure, by Year, and Average Number of Procedures by Advanced Dental Therapist per Treatment Day, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	-	-	-	-	1,021	2,550	2,871	3,329	2,910	2,659
Preventive	-	-	-	-	1,221	2,229	2,086	3,238	2,888	2,760
Restorative	-	-	-	-	1,398	2,883	2,801	3,374	2,923	2,392
Endodontics	-	-	-	-	3	42	44	53	44	26
Periodontics	-	-	-	-	13	20	10	13	31	52
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	-	76	143	126	154	189	164
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	-	113	271	217	249	314	222
Total Annual Procedures	-	-	-	-	3,845	8,138	8,155	10,410	9,299	8,275
# Treatment Days	-	-	-	-	190	353	323	357	347	298
Average Procedures/ Treatment Day	-	-	-	-	20.24	23.05	25.25	29.16	26.80	27.77

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Year in which no dental therapist was yet certified as an advanced dental therapist.

Source: Patient Encounter Data, Apple Tree Dental 2009-19.

Advanced dental therapists provided a lower proportion of restorative procedures in 2018-19 (28.9% of all procedures) than in earlier years (Table 10). The recent negative trend in proportion of restorative services per treatment day was statistically significant ($P<0.001$). A similar trend was noted for dental therapists. A third of procedures supplied by advanced dental therapists to patients in 2018-19 were preventive (33.3%); nearly half of the services provided by dental therapists in that year were preventive (49.6%) (Table 8). In 2018-19, 63.4% of patient visits by advanced dental therapists in the centers were for children under 18 years of age, an age group for whom preventive services are emphasized.

TABLE 10. Procedure Type as a Proportion of All Procedures Performed by an Advanced Dental Therapist by Year, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	P-Value[c]
Diagnostic	-	-	-	-	26.6%	31.3%	35.2%	32.0%	31.3%	32.1%	0.345
Preventive	-	-	-	-	31.8%	27.4%	25.6%	31.1%	31.1%	33.3%	0.374
Restorative	-	-	-	-	36.4%	35.4%	34.3%	32.4%	31.4%	28.9%	**<0.001**
Endodontics	-	-	-	-	0.1%	0.5%	0.5%	0.5%	0.5%	0.3%	0.557
Periodontics	-	-	-	-	0.3%	0.3%	0.1%	0.1%	0.3%	0.6%	0.324
Prosthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Oral and maxillofacial surgery	-	-	-	-	2.0%	1.8%	1.5%	1.5%	2.0%	2.0%	0.739
Orthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Adjunctive	-	-	-	-	2.9%	3.3%	2.7%	2.4%	3.4%	2.7%	0.717
Total	-	-	-	-	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	N/A

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Year in which no dental therapist was yet certified as an advanced dental therapist.

[c] P-value in bold is significant.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Production Generated by Dental Therapists and Advanced Dental Therapists Described by Relative Value Units

Average RVUs produced by dental therapists per treatment day were 24.07 in 2012-13 and 24.41 in 2018-19, a decline from the previous year (Table 11). The trend in RVUs produced by dental therapists was positive but not statistically significant ($P=0.923$).

TABLE 11. Total Number of Relative Value Units (RVUs) Produced by Dental Therapists by Type of Procedure, by Year, and Average Number of RVUs by Dental Therapist per Treatment Day, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19
Diagnostic	-	-	-	516.55	222.65	-	-	-	749.95	2,168.25
Preventive	-	-	-	1,428.50	662.90	-	-	-	1,967.10	3,876.20
Restorative	-	-	-	5,053.60	2,971.30	-	-	-	5,179.00	3,410.10
Endodontics	-	-	-	31.00	35.25	-	-	-	99.00	35.00
Periodontics	-	-	-	177.50	48.90	-	-	-	175.80	397.10
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	60.80	46.00	-	-	-	219.00	105.80
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	48.60	38.30	-	-	-	140.65	161.40
Total Annual RVUs	-	-	-	7,316.55	4,025.30	-	-	-	8,530.50	10,153.85
# Treatment Days	-	-	-	304	141	-	-	-	293	416
Average RVUs/ Treatment Day	-	-	-	24.07	28.55	-	-	-	29.11	24.41

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.

[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Restorative services accounted for 33.6% of RVUs generated per treatment day by dental therapists in 2018-2019 (Table 12) but represented 14.2% of procedures provided to patients (Table 8). Preventive services represented 38.2% of RVUs but 49.6% of patient services (Table 8). In previous years, restorative services represented between 61% and 74% of RVUs produced per treatment day by dental therapists.

TABLE 12. Proportion of RVUs Generated per Dental Therapist Treatment Day by Procedure Type and Year, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19
Diagnostic	-	-	-	7.1%	5.5%	-	-	-	8.8%	21.4%
Preventive	-	-	-	19.5%	16.5%	-	-	-	23.1%	38.2%
Restorative	-	-	-	69.1%	73.8%	-	-	-	60.7%	33.6%
Endodontics	-	-	-	0.4%	0.9%	-	-	-	1.2%	0.3%
Periodontics	-	-	-	2.4%	1.2%	-	-	-	2.1%	3.9%
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	0.8%	1.1%	-	-	-	2.6%	1.0%
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	0.7%	1.0%	-	-	-	1.6%	1.6%
Total	-	-	-	100.0%	100.0%	-	-	-	100.0%	100.0%

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.

[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Advanced dental therapists are permitted to provide more complex services, more independently than dental therapists including treatment plan formulation and extractions. The average RVUs per treatment day for advanced dental therapists increased from 31.71 in 2013-14 to 42.96 in 2018-19 (Table 13). The average RVUs per treatment day for advanced dental therapists were higher than for dental therapists (24.07 in 2013-14; 24.41 in 2018-19) working in the 2 centers in all years examined for this project (Table 11). The trend in average RVUs per treatment day by advanced dental therapists was positive and statistically significant (*P*=0.029).

TABLE 13. Total Number of Relative Value Units (RVUs) produced by Advanced Dental Therapists by Type of Procedure, by Year, and Average Number of RVUs Produced by Advanced Dental Therapist per Treatment Day, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	-	-	-	-	771.50	1,901.45	2,102.20	2,525.85	2,195.85	2,005.95
Preventive	-	-	-	-	1,101.10	1,988.70	1,891.10	2,843.00	2,656.70	2,561.90
Restorative	-	-	-	-	3,795.00	8,051.80	7,942.20	10,201.60	8,940.30	7,400.00
Endodontics	-	-	-	-	5.00	63.00	91.00	96.50	82.50	40.25
Periodontics	-	-	-	-	42.40	67.40	24.70	30.70	105.40	146.10
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	-	170.20	316.40	273.80	334.40	408.20	353.60
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	-	139.90	328.50	267.15	285.25	399.30	291.90
Total Annual RVUs	-	-	-	-	6,025.10	12,717.25	12,592.15	16,317.30	14,788.25	12,799.70
# Treatment Days	-	-	-	-	190	353	323	357	347	298
Average RVUs/ Treatment Day	-	-	-	-	31.71	36.03	38.98	45.71	42.62	42.95

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Note: Year in which no dental therapist was yet certified as an advanced dental therapist.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

RVUs produced from restorative services for patients represented the majority of RVUs (58% to 63%) produced by advanced dental therapists, on average per treatment day, in all years examined for this study (Table 14). In 2018-19, restorative procedures represented 57.8% of average daily RVUs for advanced dental therapy services but only 28.9% of all procedures provided to patients (Table 10).

TABLE 14. Proportion of RVUs Generated per Advanced Dental Therapist Treatment Day by Procedure Type and Year, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	-	-	-	-	12.8%	15.0%	16.7%	15.5%	14.8%	15.7%
Preventive	-	-	-	-	18.3%	15.6%	15.0%	17.4%	18.0%	20.0%
Restorative	-	-	-	-	63.0%	63.3%	63.1%	62.5%	60.5%	57.8%
Endodontics	-	-	-	-	0.1%	0.5%	0.7%	0.6%	0.6%	0.3%
Periodontics	-	-	-	-	0.7%	0.5%	0.2%	0.2%	0.7%	1.1%
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	-	2.8%	2.5%	2.2%	2.0%	2.8%	2.8%
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	-	2.3%	2.6%	2.1%	1.7%	2.7%	2.3%
Total	-	-	-	-	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

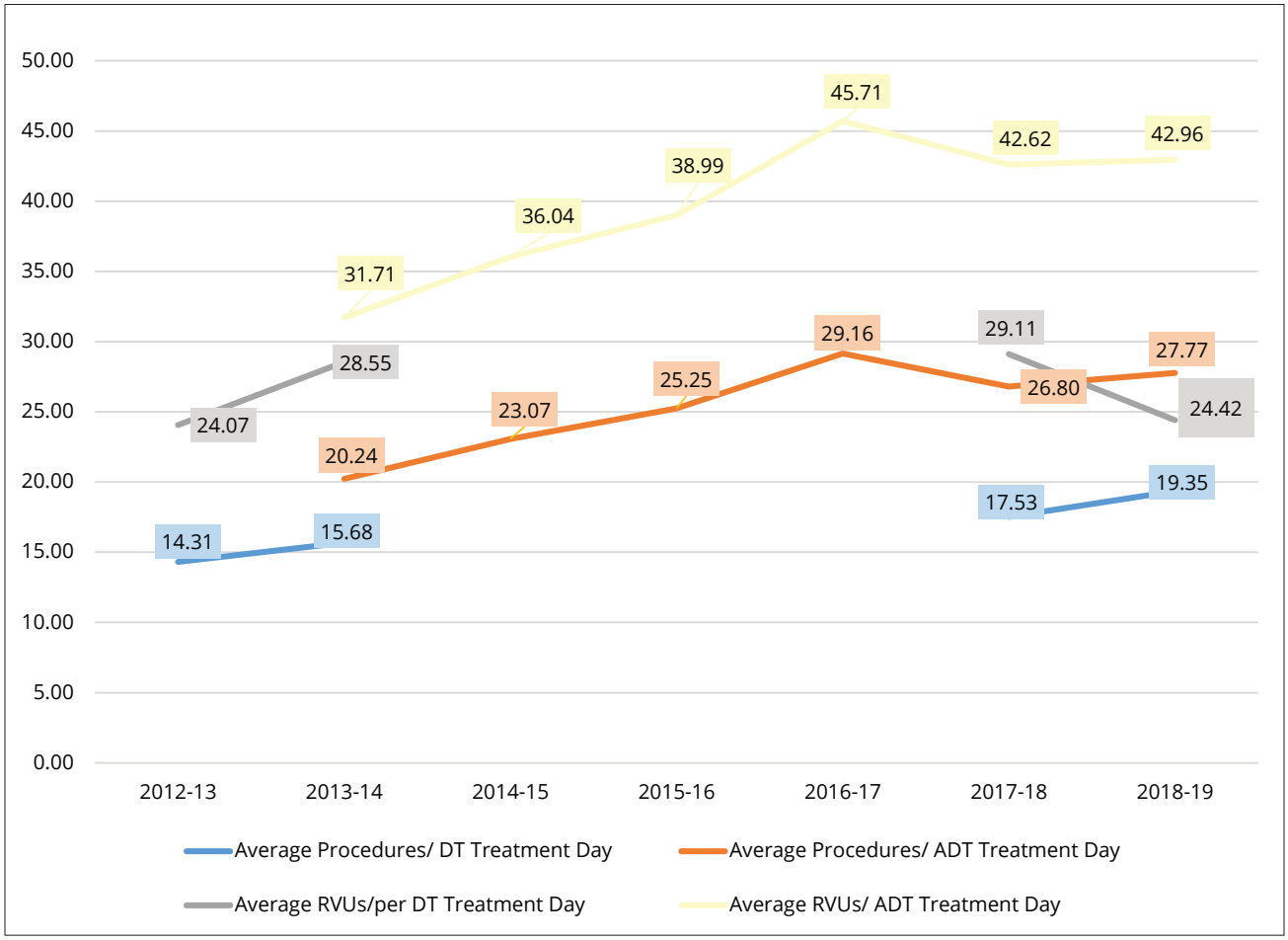
[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Year in which no dental therapist was yet certified as an advanced dental therapist.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The combined dental therapy workforce contributed capacity for patient services and support for clinical operations. The data show that the contribution of dental therapists differs somewhat from that of advanced dental therapists likely attributable to differences in levels of required supervision, allowances that permit advanced dental therapists more expansive tasks, and years of experience working in dental therapy (Figure 10).

FIGURE 10. Seven-Year Trends in Average Number of Procedures Performed by Dental Therapists and Advanced Dental Therapists per Treatment Day and Average Number of Relative Value Units (RVUs) Produced per Treatment Day, 2012-19



Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Production Generated by Dental Therapists and Advanced Dental Therapists Described by Average Fees from Procedures

Average fees per dental therapist treatment day varied by year in the 2 clinics (Table 15). The most recent year's average fees per treatment day ($1,712.98) were similar to those generated in the first year in which dental therapists were introduced to practice ($1,764.67 in 2012-13). The trend in average fees per treatment day was not statistically significant (*P*=0.892).

TABLE 15. Annual Fees Produced From Dental Therapists' Services by Procedure Type and Average Fees per Treatment Day, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19
Diagnostic	-	-	-	$36,427.40	$15,719.41	-	-	-	$54,396.93	$155,808.37
Preventive	-	-	-	$97,960.66	$46,432.55	-	-	-	$136,059.78	$262,985.94
Restorative	-	-	-	$380,744.23	$225,715.88	-	-	-	$379,554.07	$247,441.90
Endodontics	-	-	-	$2,018.62	$2,565.48	-	-	-	$7,065.83	$2,647.75
Periodontics	-	-	-	$11,386.79	$3,225.10	-	-	-	$10,829.89	$23,836.79
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	$5,019.64	$3,877.95	-	-	-	$18,017.60	$8,643.04
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	$2,900.95	$2,786.50	-	-	-	$9,817.81	$11,236.28
Total Annual Fees	-	-	-	$536,458.29	$300,322.87	-	-	-	$615,741.91	$712,600.07
# Treatment Days	-	-	-	304	141	-	-	-	293	416
Average Fees/ Treatment Day	-	-	-	$1,764.67	$2,129.95	-	-	-	$2,101.51	$1,712.98

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.
[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.
Source: Patient Encounter Data, Apple Tree Dental 2009-19.

In the first year of practice at Apple Tree Dental, 71.0% of the fees generated from dental therapists' services were for restorative procedures (Table 16). In 2018-19, 34.7% of fees generated by dental therapists were for restorative services provided to patients in the 2 centers examined for this research. More than a third (36.9%) of fees generated in 2018-19 were for preventive services supplied by dental therapists. The trends in the proportion of fees by procedure type over the 10-year period were not statistically significant except for the positive trend in the proportion of fees generated by adjunctive services that was borderline statistically significant (P=0.056).

TABLE 16. Percentage of Annual Fees Produced From Dental Therapists' Services by Procedure Type, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19	P-Value
Diagnostic	-	-	-	6.8%	5.2%	-	-	-	8.8%	21.9%	0.171
Preventive	-	-	-	18.3%	15.5%	-	-	-	22.1%	36.9%	0.154
Restorative	-	-	-	71.0%	75.2%	-	-	-	61.6%	34.7%	0.131
Endodontics	-	-	-	0.4%	0.9%	-	-	-	1.1%	0.4%	0.906
Periodontics	-	-	-	2.1%	1.1%	-	-	-	1.8%	3.3%	0.410
Prosthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Oral and maxillofacial surgery	-	-	-	0.9%	1.3%	-	-	-	2.9%	1.2%	0.647
Orthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Adjunctive	-	-	-	0.5%	0.9%	-	-	-	1.6%	1.6%	0.056
Total	-	-	-	100.0%	100.0%	-	-	-	100.0%	100.0%	N/A

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.
[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.
Source: Patient Encounter Data, Apple Tree Dental 2009-19.

Average fees per advanced dental therapist treatment day increased over time after their introduction at Apple Tree Dental in 2013 (Table 17). Average fees per advanced dental therapists' treatment day were highest in 2016-17 ($3,285.57). The trend in average fees was statistically significant (*P*=0.042).

TABLE 17. Annual Fees Produced From Advanced Dental Therapists' Services by Procedure Type and Average Fees per Treatment Day, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Diagnostic	-	-	-	-	$56,915.84	$140,925.26	$155,553.92	$187,881.30	$162,972.61	$150,389.14
Preventive	-	-	-	-	$76,315.17	$139,115.37	$131,492.83	$197,419.17	$188,373.43	$177,584.98
Restorative	-	-	-	-	$285,044.11	$603,403.43	$591,337.87	$731,439.14	$636,188.40	$524,239.06
Endodontics	-	-	-	-	$358.65	$4,580.66	$6,189.87	$6,712.33	$5,743.55	$2,924.13
Periodontics	-	-	-	-	$2,656.75	$3,537.28	$1,772.43	$2,212.02	$6,099.57	$8,819.28
Prosthodontics	-	-	-	-	-	-	-	-	-	-
Oral and maxillofacial surgery	-	-	-	-	$13,485.90	$25,699.36	$22,644.99	$27,608.02	$33,259.86	$28,689.08
Orthodontics	-	-	-	-	-	-	-	-	-	-
Adjunctive	-	-	-	-	$10,079.93	$22,963.51	$18,279.28	$19,675.37	$27,341.98	$20,741.83
Total Annual Fees	-	-	-	-	$444,856.35	$940,224.87	$927,271.19	$1,172,947.35	$1,059,979.40	$913,387.50
# Treatment Days	-	-	-	-	190	353	323	357	347	298
Average Fees/ Treatment Day	-	-	-	-	$2,341.35	$2,663.53	$2,870.81	$3,285.57	$3,054.70	$3,065.06

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Year in which no dental therapist was yet certified as an advanced dental therapist.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

In 2018-19, more than half (57.4%) of all fees generated by advanced dental therapists were for restorative services to patients and 19.4% of fees were for preventive services (Table 18). The trends in the proportion of fees by procedure type over the 10-year period were not statistically significant except for the decreasing trend in proportion of fees for restorative services produced by advanced dental therapists (*P*=0.008). Restorative procedures represented 28.9% and preventive services represented 33.3% of all services provided by advanced dental therapists to patients in 2018-19 (Table 10). Restorative procedures accounted for 57.8% of average daily RVUs produced by advanced dental therapists and preventive procedures accounted for 20.0% of advanced dental therapy RVUs in 2018-19 (Table 14).

TABLE 18. Percentage of Annual Fees Produced From Advanced Dental Therapists' Services by Procedure Type, 2009-19

Procedure Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	P-Value[c]
Diagnostic	-	-	-	-	12.8%	15.0%	16.8%	16.0%	15.4%	16.5%	0.124
Preventive	-	-	-	-	17.2%	14.8%	14.2%	16.8%	17.8%	19.4%	0.177
Restorative	-	-	-	-	64.1%	64.2%	63.8%	62.4%	60.0%	57.4%	**0.008**
Endodontics	-	-	-	-	0.1%	0.5%	0.7%	0.6%	0.5%	0.3%	0.538
Periodontics	-	-	-	-	0.6%	0.4%	0.2%	0.2%	0.6%	1.0%	0.382
Prosthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Oral and maxillofacial surgery	-	-	-	-	3.0%	2.7%	2.4%	2.4%	3.1%	3.1%	0.626
Orthodontics	-	-	-	-	-	-	-	-	-	-	N/A
Adjunctive	-	-	-	-	2.3%	2.4%	2.0%	1.7%	2.6%	2.3%	0.965
Total	-	-	-	-	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	N/A

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Year in which no dental therapist was yet certified as an advanced dental therapist.

[c] P-value in bold is significant.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The 7 Dental Centers of Apple Tree Dental

To ascertain if the findings from the 2 centers with the most consistent and continuous data related to deployment of dental therapists/advanced dental therapists at Apple Tree Dental was reasonable and generally representative of organization wide practice, a summary analysis of all patient encounter data from the 7 dental centers was conducted for the 10-year period beginning February 9, 2009 and ending July 31, 2019 (Table 19). A separate analysis (not presented here) compared the production from the 2 centers with the production from the other 5 centers. The findings from both analyses suggest that the data from the subset of 2 centers was consistent with organization wide outcomes from deployment of dental therapists/advanced dental therapists.

TABLE 19. Comparison of Average Number of Procedures, RVUs, and Fees per Treatment Day by Dentists, Dental Therapists, and Advanced Dental Therapists in 7 Dental Clinics and in the Subset of 2 Dental Clinics at Apple Tree Dental, 2009-19

Outcome Measure	7 Centers		2 Centers	
	Up to 3 Years Before Introduction of DTs[a]	Up to 3 Years After Introduction of DTs[a]	3 Years Before Introduction of DTs (2009-12)[b]	7 Years After Introduction of DTs (2012-19)[b]
Dentists				
Average # Procedures/Treatment Day	21.41	21.12	21.73	20.97
Average RVUs/Treatment Day	49.25	51.94	48.54	52.81
Average Fees/Treatment Day	$3,513.86	$3,627.96	$3,432.05	$3,684.96
Dental Therapists				
Average # Procedures/Treatment Day		15.82		17.03
Average RVUs/Treatment Day		26.33		25.88
Average Fees/Treatment Day		$1,867.09		$1,865.79
Advanced Dental Therapists				
Average # Procedures/Treatment Day		25.26		25.76
Average RVUs/Treatment Day		39.13		40.28
Average Fees/Treatment Day		$2,826.09		$2,922.29

[a] The start date for dental therapists varied across clinics.

[b] The start date in both the Coon Rapids clinic and the Madelia clinic was the same (02/06/12).

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

DISCUSSION

Apple Tree Dental mainly serves low-income patients, many of whom are Medicaid eligible and a portion of whom have special health care needs. The organization largely depends on reimbursement from public insurance programs to support operations and patient services. Thus, maximizing clinical and operational capacity is critical to sustaining the Apple Tree dental centers and mobile dental services. Administrative and clinical staff are committed to the organizational mission of serving people with special dental access needs who may experience barriers to oral health services. To achieve this goal, Apple Tree Dental has built clinical and administrative teams to efficiently deploy workforce and effectively use divergent and overlapping professional competencies to address patient need.

This study examined the quantity and type of services provided by various clinical professionals before and after introduction of dental therapy practice at Apple Tree Dental. In summary, the analyses showed that the addition of the dental therapy workforce has had positive outcomes for patients, providers, and the organization generally. The summary statistics demonstrate that currently oral health clinicians are producing more procedures and higher average RVUs and fees per treatment day than in the years prior to introduction of dental therapy. In addition, the number of clinicians and patients in the Apple Tree Dental centers increased concomitant with the introduction of dental therapists to the organization reflecting organizational expansion.

At the same time, the demographics of the patient population changed including an increase in the number of children served. Our findings suggest that, at a minimum, capacity to provide services has increased across the organization, due in part to new workforce and, as a result, access to dental services at Apple Tree Dental has increased. A previous study in Minnesota of other providers employing dental therapists found that therapists in those practices were expanding access to dental services in both rural and metropolitan areas of the state.[2]

Common concerns among stakeholders about the dental therapy workforce found in peer reviewed literature[8,9,10] include discussions about the quality of dental therapy services in comparison to those supplied by dentists as well as the potential for substitution of dentists by dental therapists should the model proliferate; dental therapists are less expensive to employ by virtue of the shorter and less costly training trajectory. Critics describe a danger to patients should the delivery system broadly embrace such substitution.

This study found that overlapping clinical skills among dentists, dental hygienists, and dental therapists result in substitution for restorative services traditionally provided by dentists and for preventive services historically provided mainly by dental hygienists. However, this finding may also be framed in terms of complementarity in skills that allows for redistribution of workload across the dental team. The corresponding skills of dental therapists, especially in basic restorative services, appear to permit dentists to use their clinical expertise and extensive training to provide more advanced patient services. The positive

impacts of redistribution of services to various clinical professionals are most apparent when organizational capacity is increased to allow for more patients and shorter waiting times to see clinical providers.

The past introduction of nurse practitioners and physician assistants to medical practices in the US is often cited as a parallel to current changes in dentistry. In medicine, "mid-level" providers bring clinical skills to their practices that permit physicians to practice at higher levels of medical expertise. In dentistry, the "upskilling" of workforce and expansions in scopes of practice for members of the oral care team permit dentists to more often use higher levels of clinical proficiency. Expanded function dental assistants, public health dental hygienists, and in some states, dental therapists are able to extend capacity and enable effective use of their acquired competencies affording dentists the opportunity to spend more time on advanced procedures. The increase in average daily RVUs among dentists at Apple Tree is evidence of the delivery of more advanced services to patients.

One of the findings from this study is that while the distribution of services by type has not changed substantially since the dental therapy workforce joined the dental teams, the value of the services provided within different procedural categories has increased. In 2009-10 the average proportions of services by dentists by type showed that 38.1% were diagnostic services, 32.2% were restorative services, 11.3% were preventive services, and the remainder were classified as specialty services including oral and maxillofacial surgery and prosthodontics. In 2018-19, 7 years after introduction of dental therapy to the clinical team, the average daily proportion of dental procedures for dentists by type showed that 43.9% were diagnostic, 33.8% were restorative, and 8.2% were preventive with the remainder classified as specialty services.

Dentists, dental therapists, and advanced dental therapists commonly provide restorative services. In 2018-19, on average, 33.8% of dentists' services, 28.9% of advanced dental therapists' services, and 14.2% of dental therapists' services were restorative procedures. On average, more than half (57.4%) of annual fees for services by advanced dental therapists, 49.9% of annual fees from services by dentists, and 34.7% of annual fees from dental therapists' services were for restorative procedures.

Average RVUs per treatment day for dentists progressed from 51.56 in 2009-10 to 60.19 in 2018-19. The most pronounced differences in production value were for restorative procedures which averaged 22.15 RVUs per treatment day in 2009-10 rising to 28.86 in 2017-18 and 30.38 in 2018-19. A rise in average daily RVUs for diagnostic services was also noted. Average RVUs per treatment day for those services in 2009-10 were 6.53 changing to 8.10 in 2017-19 and 8.89 in 2018-19.

The number of restorative procedures constituted, on average, just over one third of daily dental services yet they constituted 50.5% of daily RVUs produced by dentists. Average daily RVUs produced by advanced dental therapists in 2018-19 were 42.95. Of those, more than half (24.83; 57.8%) were for restorative services.

Other data points inform the finding of increased production after introduction of dental therapy to the clinical teams. The average daily number of procedures by dentists during the period increased from

21.69 in 2009-10 to 25.61 in 2018-19. Additionally, in 2009-10, dentists in the 2 clinics completed, on average, 10.9 patient visits per treatment day; that number increased to 13.8 in 2018-19.

These findings are particularly interesting considering that most patients at Apple Tree Dental are low income and many have Medicaid benefits or no dental insurance which may limit or constrain options and patient choice relative to higher end restorative or treatment procedures. For an organization with a mission to provide preventive and primary dental care for underserved populations and a need for efficient available capacity to meet patient demand, the results from this study provide a potentially meaningful reason to add dental therapists to the clinical team.

The data would suggest that one of the most immediate impacts of new workforce with dual competencies is to supply flexible, productive capacity to treat increasing patient caseloads. In 2011-12, the year prior to first employment of dental therapists, the number of patient visits in the 2 dental centers was 22,665 (data not shown). In 2018-19, clinical staff completed 27,558 patient visits in those centers. Beazoglou and co-authors[3] conducted a study in Colorado to understand how the addition of expanded function allied personnel affected dental practices. The authors found that effective use of workforce had the potential to substantially increase both capacity and productivity of a dental practice. The example of Apple Tree Dental further supports this finding.

While extensive analysis and comparison of preventive services provided by dental therapists or advanced dental therapists with those provided by dental hygienists was not conducted for this study, it is apparent from this data that many preventive services are being provided by dentists, advanced dental therapists, and especially by dental therapists. There are several possible explanations for this trend including that many therapists in Minnesota are also dental hygienists. Another is that the number of patients who are children has noticeably increased at the dental centers. In the most recent year, 35.8% of dentist visits, 48.3% of dental therapist visits, and 63.4% of advanced dental therapist visits were for children under 18 years of age, a cohort in which prevention is emphasized. These changes may also be indicative of the general paradigm shift in dentistry away from diagnosis and treatment to prevention and early intervention in oral disease processes. A study of the impacts of dental therapy practice on the workload of dental hygienists and provision of preventive services was beyond the scope of this research but is a topic for future study.

Other findings which warrant further research are differences in workload distribution between dental therapists and advanced dental therapists. Dental therapists provided more preventive services (49.6% of services) and fewer restorative services (14.2% of services) in 2018-19 than in past years. In 2018-19, 33.3% of services by advanced dental therapists were preventive and 28.9% were restorative. All dental therapists and advanced dental therapists in the 2 centers possess dental hygiene licenses so supplying preventive services for patients when needed would be a reasonable expectation. A recent shortage of dental hygienists to work in the dental centers under study resulted in more preventive services being provided by dental therapists on staff at those locations. This response is evidence of the value of a workforce that can respond immediately to fluctuations in service demand and patient workflow.

While dentists and dental hygienists traditionally have more particular expertise in restorative or preventive procedures respectively, dental therapists/advanced dental therapists are not identified with exclusive competencies. In fact, their uniqueness is grounded in education and training in some proficiencies of both disciplines. Opportunities to adjust daily workflow according to presenting patient need are increased by the presence of professionals with skills in both preventive and restorative dentistry.

Preliminary interviews and discussions with staff at Apple Tree Dental to clarify project objectives preceded the quantitative analyses presented here. In group discussion, several staff commented that dental therapists and advanced dental therapists were prized for their flexibility observing that their training results in a clinical provider with perspectives that bridge dentistry and dental hygiene. Staff noted that one benefit of including dental therapists in the workforce is that prevention and treatment planning have improved in both tangible and intangible ways in the dental centers managed by Apple Tree Dental. The new workforce has created synergies within the organization that were not previously present or at least not apparent. Several people also commented on the increased capacity for patient visits from additional workforce enabling earlier intervention in disease processes. These anecdotal findings, which suggest impacts on quality, should be confirmed with future research activities to support their validity.

It is not possible to determine that the beneficial outcomes at Apple Tree Dental are attributable only to adding dental therapy practice to the workforce or that these findings are generalizable. During the extended period included in this study, many environmental changes occurred which cannot be fully evaluated. The Medicaid program in the state adjusted the adult dental benefit on numerous occasions affecting both service mix and patient choice. However, it seems unlikely given the public insurance environment and low reimbursement rates that outcomes such as increased capacity to provide services, higher average intensity of services, increased numbers of procedures, and generation of higher average fees would not be due, at least in part, to the addition of workforce with bridging competencies.

Apple Tree Dental is positioned in the delivery system as a non-profit community dental organization providing services in the oral health safety net. Demand for services is growing as evidenced by increases in the number of patients seeking services in the dental clinics annually. The organization has integrated dental therapy into practice over the 7 years since it was introduced to the state and has benefitted from the workforce in capacity and flexibility to provide oral health services to meet rising demand from its patient population.

LIMITATIONS

There are limitations to the work presented in this report. The impact of employing dental therapists/advanced dental therapists is difficult to entirely disentangle from the dynamic structure of a large organization like Apple Tree Dental. Shifts in production noted in this report may not be directly attributable to changes in workforce but rather to, for instance, growth in the patient population or shifts in demographics and oral health needs of that population. Over time, Apple Tree Dental has moved from serving

a patient population dominated by elders to serving a large population of children (see Appendix B). Thus, service mix over time would differ based on demands from pediatric versus adult or geriatric populations. Understanding shifts in service mix based on patient demographics was not the objective of this research but these demographic shifts could certainly impact outcomes from this research.

Another intervening factor during the study period was change in the quality of the adult dental benefit in the Medicaid program in Minnesota. In 2018, about 81% of patients at Apple Tree Dental were insured by Medicaid or Minnesota Care. Thus, changes in state Medicaid dental policy had a significant impact. In 2009, in response to the economic downturn, the state legislature substantially limited the adult Medicaid dental benefit set and changed the fee schedule for the remaining benefits. Although there has been an incremental restoration of a few covered services in subsequent years, the original comprehensive benefit set has not been restored. The reduction in the dental benefit immediately effected only Medicaid beneficiaries who were Fee for Service patients, enrolled with the Minnesota Department of Human Services. The managed care organizations' annual contract, which included eliminated benefits, was not reduced until the next contractual period so patients enrolled in managed care were affected at a later time. Thus, the impact on service mix at Apple Tree Dental occurred over a protracted period. While low income patients at Apple Tree Dental are eligible to pay for non-covered services on a sliding fee scale, the quality of the Medicaid benefit affects patient choices. Many of the higher level, higher cost procedures were no longer covered influencing patients' treatment plan acceptance and the service mix provided. Again, this is one of many factors that might affect fluctuations in the types of services.

In addition, a paradigm shift in dentistry occasioned by emerging science, new technology and materials, and policy and payment initiatives has resulted in an increased emphasis on prevention and a reduced emphasis on restorative care. Interest in caries risk management and protocols for early intervention have also affected the services provided to patients. Thus, shifts in services may be caused in part by greater emphasis on primary, secondary, or tertiary prevention.

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APPENDIX A

APPENDIX A: DEMOGRAPHIC CHARACTERISTICS OF DENTAL THERAPISTS

The Minnesota Department of Health collects data on licensed dental therapists in the state through ongoing surveys. The information described below was collected in a March 2019 survey of dental therapists licensed in Minnesota in 2018. The survey was e-mailed to 92 dental therapists including those credentialed as advanced dental therapists; the survey response rate was 66%. The separate information presented on dental therapists at Apple Tree Dental was obtained in the same survey from the dental therapists/advanced dental therapists employed at Apple Tree Dental at the time of the survey. Dental therapists at Apple Tree Dental in that year were female, mainly white, and the majority (72%) had a Master's degree (Table 20).

TABLE 20. Demographic Characteristics of Dental Therapists (DTs) in Minnesota and at Apple Tree Dental, 2018

Characteristics of DTs	MN DTs	Apple Tree Dental DTs
Gender		
Male	14.0%	0.0%
Female	86.0%	100.0%
Age Group		
<34	57.0%	57.0%
35-44	22.0%	29.0%
45-54	17.0%	14.0%
55-64	4.0%	
Median Age	33	29
Race/Ethnicity[a]		
Black/African American	2.0%	
African	2.0%	
Middle Eastern/North African	2.0%	
Asian-Southeast Asian	2.0%	
Asian- South Asia	4.0%	
Asian-Other	5.0%	
American Indian/Alaska Native	4.0%	
White	82.0%	86.0%
Hispanic/Latino	5.0%	
Unknown		14.0%
Languages Spoken in Practice		
English	89.0%	86.0%
Spanish	9.0%	
Hmong	2.0%	
Unknown		14.0%
Educational Attainment		
Certificate, certification, other post Bachelor's credential	9.0%	
Master's degree	67.0%	72.0%
Certificate, certification, other post Master's credential	24.0%	14.0%
Unknown		14.0%

[a] DTs were permitted to select multiple racial groups so the total exceeds 100%.
Source: Minnesota Department of Health, Minnesota's Dental Therapist Workforce, September 2019.

Dental therapists working at Apple Tree Dental mainly worked at one location; however, 29% of dental therapists provided services at 3 or more locations served by the organization (Table 21).

TABLE 21. Work Status and Employer Type, Dental Therapists (DTs) in Minnesota and at Apple Tree Dental, 2018

Work Status	MN DTs	Apple Tree Dental DTs
Working in paid or unpaid position related to dental therapy	95.0%	100.0%
Full-time	95.0%	100.0%
Average hours worked per week	36	39.6
Number of work sites		
1	58.0%	71.0%
2	28.0%	0.0%
3 or more	14.0%	29.0%
Employer		
Community/Faith Based Organization	25.0%	100.0%
Solo Private practice	25.0%	
Small Group Private practice (2 to 4 dentists)	16.0%	
Community Health Center/ FQHC	14.0%	
Large Group Private Practice (5+ dentists)	12.0%	
Academic (Teaching/Research)	4.0%	
School (K-12)	3.0%	
Hospital	1.0%	
Mobile Dental Clinic	0.0%	
Other	0.0%	

Source: Minnesota Department of Health, Minnesota's Dental Therapist Workforce, September 2019.

More than 70.0% of those licensed to practice dental therapy in Minnesota are advanced dental therapists (ADTs) (Table 22). In 2018, 29% of the dental therapists at Apple Tree Dental were certified as an advanced dental therapist and an additional 29.0% were in the process of becoming certified. Advanced dental therapists at Apple Tree Dental indicated that up to 25% of their work time was spent working under general supervision, a situation in which the collaborating dentist is not present at the same location as the ADT. More than half (57%) of advanced dental therapists at Apple Tree Dental were also licensed as dental hygienists and all performed dental hygiene services at Apple Tree Dental.

TABLE 22. Work Characteristics of Advanced Dental Therapists (ADTs) in Minnesota and at Apple Tree Dental, 2018

Work of Advanced Dental Therapists	MN DTs	Apple Tree Dental DTs
Certified as an ADT		
Yes	70.0%	29.0%
No	12.0%	43.0%
In process of certifying	18.0%	29.0%
% of time ADT performs evaluations and extractions (CDT codes D0120, D0140, D0145, D7140)		
Up to 25% of my time	35.0%	
25%-49% of my time	38.0%	50.0%
50%-74% of my time	13.0%	
More than 75% of my time	12.0%	50.0%
None	3.0%	
% of time ADTs work under general supervision (collaborating dentist not present at location)		
Up to 25% of my time	35.0%	100.0%
25%-49% of my time	23.0%	
50%-74% of my time	5.0%	
More than 75% of my time	17.0%	
None	20.0%	
Licensed as a Dental Hygienist (DH)		
Yes	42.0%	57.0%
No	58.0%	43.0%
Job requires performance of tasks within the DH Scope		
Yes	92.0%	100.0%
No	8.0%	
% of time spent performing DH tasks		
Up to 25% of my time	62.0%	50.0%
25%-49% of my time	14.0%	25.0%
50%-74% of my time	14.0%	25.0%
More than 75% of my time	5.0%	0.0%
None	5.0%	0.0%

Source: Minnesota Department of Health, Minnesota's Dental Therapist Workforce, September 2019.

Dental therapists/advanced dental therapists in Minnesota and those employed at Apple Tree Dental were treating a broad range of underserved patient groups in their clinical practices in 2018 (Table 23).

TABLE 23. Types of Underserved Patient Groups Treated Daily by Advanced Dental Therapists (ADTs) in Minnesota and at Apple Tree Dental, 2018

Types of Underserved Patient Groups Served Daily by DTs and ADTs	MN DTs and ADTs	Apple Tree Dental DTs and ADTs
Low income or uninsured patients	100.0%	100.0%
Minnesota Health Care program recipients	92.0%	100.0%
Other racial or ethnic minority members	85.0%	100.0%
Populations with disabilities	81.0%	86.0%
Patients who require an interpreter	74.0%	71.0%
Immigrants and refugees	62.0%	57.0%
Veterans	47.0%	43.0%
Unsure	2.0%	

Source: Minnesota Department of Health, Minnesota's Dental Therapist Workforce, September 2019.

In 2020, Apple Tree Dental employed 10 dental therapists/advanced dental therapists who worked either full time or part time in 1 or more of its 7 centers. All but one dental therapist was female; 5 had attained advanced certification; 90% were white and 10% were Asian. Average age was 35 years.

APPENDIX B

APPENDIX B: PATIENTS AT APPLE TREE DENTAL

Age of Patients

An analysis of patient demographics in the two centers at Coon Rapids and Madelia revealed a noticeable increase in the percentage of patient visits by children (Table 24). In 2009-10, about one quarter of patient visits by dentists were for children (24.7%), almost two-thirds of patients served were adults (63.1%), and the remainder were elders (12.2%). By 2018-19, more than a third of dentists' patient visits were for children (35.8%), 53.7% were for working age adults, and the remainder (10.5%) were for adults age 65 years or older. The trends in the proportion of patient visits by age over the 10-year period were statistically significant for a positive trend among children (*P*=0.004) and negative trends among adults (*P*=0.009) and the elderly (*P*=0.030). As the proportion of visits for children increased, the average number of patient visits per treatment day also increased over the 10-year period; the increasing trend was statistically significant (*P*=0.018). This shifting demographic would impact the nature of services and the time required for treatment since children's oral health needs vary from adults.

TABLE 24. Age Distribution of Patients as a Proportion of Annual Patient Visits and Average Number of Patient Visits per Dentist Treatment Day, 2009-2019

Age	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	P-Value[b]
Children (<18 years)	24.7%	27.0%	25.9%	25.0%	25.3%	25.0%	27.4%	35.0%	34.3%	35.8%	**0.004**
Adults (18 to 64 years)	63.1%	62.4%	63.7%	64.1%	64.3%	64.6%	62.2%	54.8%	55.8%	53.7%	**0.009**
Elderly (65+ years)	12.2%	10.6%	10.4%	10.8%	10.5%	10.4%	10.4%	10.1%	9.8%	10.5%	**0.030**
Total All Patients	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	N/A
Average # Patient Visits/Treatment Day	10.9	10.4	10.4	10.0	10.0	10.4	10.6	11.6	12.7	13.8	**0.018**

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] P-values in bold were significant.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Dental therapists were treating children and adults in relatively equal proportion in most years with the exception of 2017-18 when 56.1% of patient visits to dental therapists were by children (Table 25). The average number of visits per treatment day increased from 5.8 in 2012-13 to 7.0 in 2018-19. None of the trends in the proportion of patient visits by age over the study period was statistically significant.

TABLE 25. Age Distribution of Patients as a Proportion of Annual Patient Visits and Average Number of Patient Visits per Dental Therapist Treatment Day, 2009-2019

Age	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19	P-Value
Children (<18 years)	-	-	-	43.8%	46.7%	-	-	-	56.1%	48.3%	0.434
Adults (18 to 64 years)	-	-	-	52.0%	49.8%	-	-	-	38.4%	44.7%	0.289
Elderly (65+ years)	-	-	-	4.2%	3.5%	-	-	-	5.5%	7.0%	0.135
Total All Patients	-	-	-	100.0%	100.0%	-	-	-	100.0%	100.0%	N/A
Average # Patient Visits/Treatment Day	-	-	-	5.8	6.1	-	-	-	7.1	7.0	0.089

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.

[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

When advanced dental therapists first practiced in the 2 clinics in 2013-14 the proportion of patient visits for children (47.4%) and working age adults (47.1%) was about equal (Table 26). In 2018-19, the proportion of patient visits provided by advanced dental therapists for children increased such that more than 6 of every 10 visits were for children (63.4%). The trends in the proportion of patient visits by age over the 6-year period were statistically significant for a positive trend among children (P=0.003) and negative trends among adults (P=0.002) and the elderly (P=0.012). The average number of patient visits per treatment day also noticeably increased from 8.2 in 2013-14 to 13.0 in 2018-19; however, the increasing trend was borderline statistically significant (P=0.055). The increases in average daily visits may be due to differences in service complexity and required time for treatment of children versus adults as well as increased provider efficiency from greater experience. In addition, those dental therapists who achieved advanced status were able to provide patient examinations (D0120 and D0140) at hygiene recall or emergency appointments.

TABLE 26. Age Distribution of Patients as a Proportion of Annual Patient Visits and Average Number of Patient Visits per Advanced Dental Therapist Treatment Day, 2009-2019

Age	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	P-Value[c]
Children (<18 years)	-	-	-	-	47.4%	48.5%	51.6%	59.8%	64.1%	63.4%	**0.003**
Adults (18 to 64 years)	-	-	-	-	47.1%	45.9%	43.1%	36.0%	32.0%	32.5%	**0.002**
Elderly (65+ years)	-	-	-	-	5.5%	5.6%	5.3%	4.2%	4.0%	4.1%	**0.012**
Total All Patients	-	-	-	-	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	N/A
Average # Patient Visits/Treatment Day	-	-	-	-	8.2	10.6	12.2	13.1	11.5	13.0	0.055

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Year in which no dental therapist was yet certified as an advanced dental therapist.

[c] P-values in bold were significant.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

Dental Insurance and Payment Status of Patients

The predominate share of patients at the Apple Tree Dental clinics are low-income and/or Medicaid eligible; thus, the mix of patients by insurance type was relatively consistent across provider types in the organization (Table 27-29). Dentists, dental therapists, and advanced dental therapists predominately treat Medicaid insured patients. The proportion of patients with Medicaid benefits increased after implementation of the ACA related Medicaid expansion in Minnesota.

The trends in the proportion of patient visits to a dentist by insurance type over the 10-year period were statistically significant for a positive trend among Medicaid insured patients (P<0.001) and a negative trend among patients on sliding fees scale (P=0.002), commercial insurance (P=0.014), and PPO (P<0.001) and a negative trend among patients on private pay that was borderline statistically significant (P=0.053) (Table 27).

TABLE 27. Proportion of Dentists' Patients by Insurance Type, 2009-2019

Insurance Type	2009-10[a]	2010-11*	2011-12[a]	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Medicaid	67.7%	67.7%	67.9%	68.1%	68.8%	73.0%	74.3%	73.5%	74.8%	77.1%
Sliding Fee Scale	4.4%	3.5%	2.9%	3.2%	2.9%	2.6%	2.6%	2.6%	2.8%	2.1%
Private Pay	3.8%	4.7%	5.4%	5.1%	5.6%	4.8%	3.6%	3.5%	3.0%	3.1%
Commercial	2.2%	2.3%	2.5%	2.3%	2.4%	2.2%	2.0%	1.8%	1.9%	2.0%
PPO	21.9%	21.6%	21.2%	21.3%	20.2%	17.5%	17.5%	18.6%	17.4%	15.7%
Head Start	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Veterans	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The trends in the proportion of patient visits to a dental therapist by insurance type over the study period were statistically significant for a positive trend among Medicaid insured patients (P=0.003) and a negative trend among patients in a PPO (P=0.019) (Table 28).

TABLE 28. Proportion of Dental Therapists' Patients by Insurance Type, 2009-2019

Insurance Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13	2013-14	2014-15[b]	2015-16[b]	2016-17[b]	2017-18	2018-19
Medicaid	-	-	-	69.6%	72.9%	-	-	-	76.4%	81.0%
Sliding Fee Scale	-	-	-	3.4%	1.4%	-	-	-	2.4%	1.6%
Private Pay	-	-	-	3.6%	2.8%	-	-	-	2.2%	2.5%
Commercial	-	-	-	2.4%	3.5%	-	-	-	2.0%	1.8%
PPO	-	-	-	21.0%	19.4%	-	-	-	17.0%	13.1%
Head Start	-	-	-	0.0%	0.0%	-	-	-	0.0%	0.0%
Veterans	-	-	-	0.0%	0.0%	-	-	-	0.0%	0.0%
Total	-	-	-	100.0%	100.0%	-	-	-	100.0%	100.0%

[a] Shaded area represents the 3-year period prior to introduction of dental therapy to the clinics.
[b] Shaded area represents the 3-year period in which there were only advanced dental therapists in the clinics.
Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

The trends in the proportion of patient visits to an advanced dental therapist by insurance type over the 6-year period were statistically significant for a positive trend among Medicaid insured patients (*P*=0.032) and a negative trend for patients in a PPO (*P*=0.007) (Table 29).

TABLE 29. Proportion of Advanced Dental Therapists' Patients by Insurance Type, 2009-2019

Insurance Type	2009-10[a]	2010-11[a]	2011-12[a]	2012-13[b]	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Medicaid	-	-	-	-	70.7%	71.6%	72.3%	74.3%	75.3%	73.6%
Sliding Fee Scale	-	-	-	-	3.1%	2.9%	2.6%	2.7%	2.4%	2.9%
Private Pay	-	-	-	-	3.3%	3.2%	3.1%	1.6%	1.6%	2.2%
Commercial	-	-	-	-	2.8%	2.6%	2.7%	2.1%	2.5%	2.8%
PPO	-	-	-	-	20.1%	19.7%	19.3%	19.3%	18.2%	18.5%
Head Start	-	-	-	-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Veterans	-	-	-	-	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Total	-	-	-	-	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[a] Shaded area represents 3-year period preceding introduction of dental therapy.

[b] Year in which no dental therapist was yet certified as an advanced dental therapist.

Source: Patient Encounter Data, Apple Tree Dental, 2009-19.

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Ms. Langelier assists the Director in preparation of all oral health related research projects, reports, and dissemination activities. Ms. Langelier has served as a project director at CHWS for 2 decades, where she has been responsible for supervising staff and coordinating of all aspects of project workflow. During her tenure, Ms. Langelier has been lead staff or the principal investigator on numerous research projects about the allied health and oral health workforce.

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