FACTORS AND OUTCOMES ASSOCIATED WITH DENTAL CARE USE AMONG MEDICAID-ENROLLED ADULTS

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DEDICATION

I dedicate this work to my husband, without whom none of my aspirations and dreams would have come true, and to my children who inspire me with their endless support and love. I know you all sacrificed to help me reach this goal. I am forever grateful.

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Heather Lynn Taylor

FACTORS AND OUTCOMES ASSOCIATED WITH DENTAL CARE USE AMONG MEDICAID-ENROLLED ADULTS

Poor oral health is associated with pain, decreased chewing function, negative social perceptions, and reduced quality of life. Low-income adults disproportionally have worse oral health and use dental services at lower rates than higher-income adults. This disparity is associated with individual demographic and socioeconomic factors, cost and coverage barriers, as well as the supply and location of dental providers. Although the full causal pathway remains elusive, evidence suggests an association with poor oral health and an exacerbation of chronic diseases symptoms. Thus, adequate provision of dental care has important population health implications. Despite this importance, dental care use among low-income adults is particularly underexplored. Furthermore, existing research lacks robust methodological designs to mitigate bias from unobserved confounders. Dental coverage for low-income adults through Medicaid is emerging as a way to provide services to this population. However, given state budget constraints, comprehensive public dental benefits are uncommon or at risk of being cut. Therefore, it is important to quantify the individual and economic value of dental care use among adult Medicaid enrollees.

This dissertation examines factors and outcomes associated with dental care use among Medicaid-enrolled adults in Indiana. This dissertation includes three studies 1) a pooled cross-sectional analysis that measures the association of individual and community level factors with dental care use, 2) a repeated measures study with individual fixed effects to examine whether receipt of preventive dental care is associated

with fewer subsequent non-preventive dental visits and lower total annual dental expenditures, and 3) an empirical study that utilizes an instrumental variable estimation method to examine the effect of preventive dental visits on medical and pharmacy expenditures. Overall, this dissertation attempts to understand the correlates of dental care use, the effectiveness of preventive dental care, and the association between preventive dental care and medical expenditures.

Justin Blackburn, PhD, Chair

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CHAPTER ONE

INTRODUCTION

Introduction

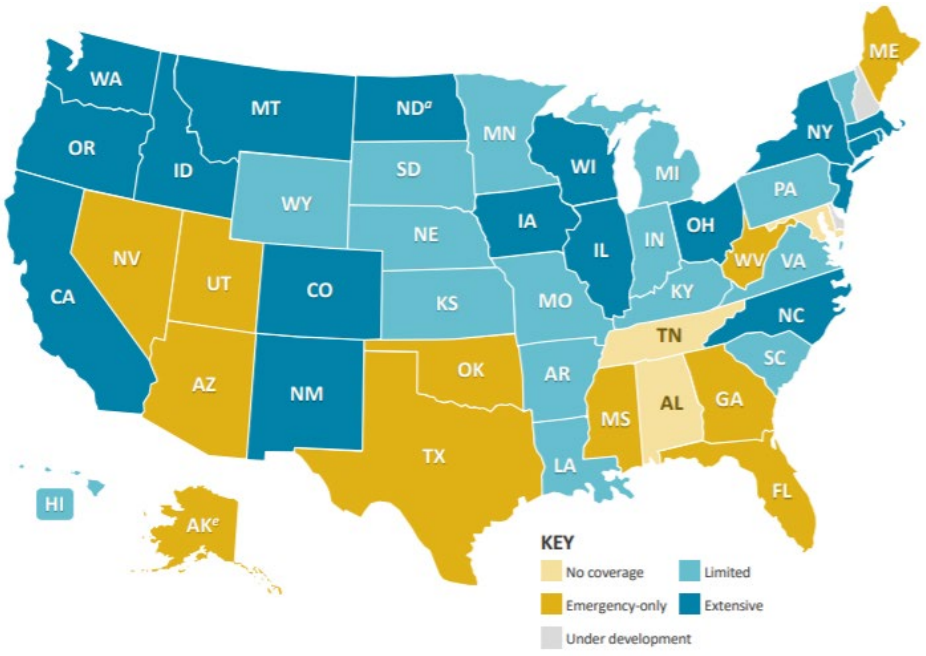
Maintaining oral health among low-income adults remains a significant public health challenge in the United States. Low-income adults disproportionately face greater barriers to assessing dental care, and are more likely to suffer from poor oral health than other adults.[1–3] While caries prevalence rates have been trending downward among adults with income at or above 200% of the federal poverty level (FPL), the prevalence of caries among low-income adults (<200% FPL) has not decreased since 1999.[4] Similarly, tooth loss (including edentulism or loss of all natural teeth) has also significantly declined among adults since 1999, but not among adults living in poverty.[1] Further, 42% of all adults over the age of 30 have a form of periodontal disease[1], but this prevalence rate is 60% among low-income adults.[6] Overall, these statistics are concerning since caries, tooth loss, and gum disease are associated with numerous adverse outcomes such as pain,[7,8] decreased chewing function,[9] poor emotional and mental health,[10–12] negative social perceptions[13] and reduced quality of life.[14–17]

Given the sizable burden of oral diseases and their potential impact on physical, psychosocial and general well-being, interventions are needed to improve oral health, particularly among low-income populations. Yet low-income adults are 40% less likely to have an annual dental visit and they are more likely to seek care for non-emergent dental

[1] The World Health Organization characterizes periodontal disease by "bleeding or swollen gums (gingivitis), pain and sometimes bad breath. In its more severe form, the gum can come away from the tooth and supporting bone, causing teeth to become loose and sometimes fall out."[6–8]

issues in hospital emergency departments than other adults.[18,19] The most common reasons these adults forgo regular dental care is related to costs.[20] In response to these financial barriers, experts advocate for dental coverage for low-income adults through Medicaid.[21] While states are required to provide comprehensive dental coverage for Medicaid-enrolled children, benefits for adults are optional.[18] As a result, states vary in the delivery and breadth of services provided to Medicaid-enrolled adults (See Figure 1). Some states provide no coverage, some provide coverage of emergency dental care for pain or traumatic dental injuries, some provide limited dental coverage of certain diagnostic, preventive, and minor restorative procedures, and some provide extensive comprehensive dental coverage including diagnostic, preventive, minor and major restorative services.[20]

Figure 1: State Medicaid Coverage of Adult Dental Benefits, September 2019[21]



Currently, 37 states and the District of Columbia have expanded dental coverage to a larger low-income adult population under the Affordable Care Act.[22] Evidence suggests that among low-income adults' dental care utilization has increased and dental care emergency department visit use has decreased, in part as a result of recent Medicaid expansions.[23–25] However, the positive effect of increased dental benefits for low-income adults has not been homogenous across all states, raising questions as to whether state policies that only address coverage barriers to dental care sufficiently lead to downstream improvements in oral health outcomes.[24,26] While Medicaid dental benefits are positively associated with greater dental care utilization, there are other factors that could negatively affect realized access and diminish the intended impact of coverage. For instance, Wehby et al. (2019) found that Medicaid expansion increases the use of dental care among low-income adults, but only in states with a high supply of dentists and comprehensive or "extensive" dental benefit coverage.[24] Low-income adults with Medicaid dental coverage often struggle to locate a dentist, as less than half of all dentists (39%) in the United States accept and participate in Medicaid programs.[27] Evidence also suggests that among dentists who do participate in Medicaid, a considerable number of providers limit how many Medicaid-enrolled individuals they treat.[27–30] Maxey et al. found that 25% of dentists enrolled in Indiana Medicaid in 2015 were inactive, meaning they submitted no Medicaid dental claims for the fiscal year.[27] Furthermore, the distribution of providers is a concern, with over 56 million Americans living in dental health professional shortage areas.[31] Beyond these community-level factors, previous studies on U.S. adults have found several factors are also correlated with dental care use, including education,[32] rural/urban residence,[33] age, sex, race/ethnicity, and smoking status.[34] Given that low-

income adults face greater barriers to accessing dental care and have worse oral health than other adults, it is important to study factors beyond dental coverage that are associated with dental care use in this population. Factors that negatively influence access despite reduced financial barriers may necessitate additional policy interventions.

At the national level, a few studies have identified state program variation of covered services and dentists per population to be relevant factors associated with use of dental care among Medicaid-enrolled adults.[24,28,35] However, these previous studies have been unable to account for certain community- and individual-level factors, such as travel distance to a dentist or access to a dentist who accepts Medicaid. A larger body of work has explored the use of dental care among Medicaid-enrolled children and found geographic access and the supply and participation of dentists in Medicaid to be significant predictors of dental care use.[36–42] However, these analyses have not been replicated among Medicaid-enrolled adults who have different oral health and access needs than children.[43,44] Understanding what barriers beyond coverage encourage or prevent low-income adults from seeking appropriate and timely dental care is important, especially since these individuals are disproportionality more likely to suffer from poor oral health. Findings could facilitate the design of effective and sustainable policy interventions that lead to improved population oral health outcomes.

Not all states cover preventive dental care for Medicaid-enrolled adults despite common recommendations from clinicians that adults should visit a dentist every 6-12 months.[18,45] Routine dental care allows for early identification of oral diseases, preventive care and/or tailored delivery of oral hygiene education, all of which may prevent more serious or extensive disease(s) and treatment(s).[40,46,47] Nevertheless, evidence as to

whether preventive dental care reduces subsequent adverse oral health outcomes among adults is sparse. Evidence among children suggests preventive dental care may be cost-effective.[48–50] One robust study among Medicaid-enrolled children found preventive dental care reduces the likelihood of future non-preventive dental visits and expenditures. The study controlled for unobserved characteristics within a child that have an effect on both use of preventive and restorative dental care but remain constant over time.[51] Considerably less research however, has been conducted among adults to determine whether routine and preventive dental care leads to improved outcomes, and in particular among low-income adults who tend to have worse oral health.[52] Since low-income adults have higher rates of untreated caries, periodontal disease, and tooth loss than other adults, it is important to determine whether routine and preventive dental care leads to improved oral health outcomes, especially for this disadvantaged population.[1,4,6] It is also important to understand the impact of these services from a public insurance program perspective, since states frequently cut or reduce adult dental benefits when budgets are constrained.[43,53,54]

Reports from private insurance companies suggest regular adult preventive dental care results in lower overall dental expenditures. In 2019, Cigna, a private health and dental insurance company, reported total savings of 31% per enrolled adult who received at least one preventive dental visit (one dental cleaning) a year. Savings were generated from lower costs in restorative, endodontic (e.g. root canal), and prosthodontic care (e.g. crown and bridge).[55] Guardian, another private health insurer, reported in 2017 that covered employer groups with greater (13% more) preventive dental care spending experienced 86% savings on major restorative dental services and 16% total dental cost

savings over a six-year period than employer groups with low preventive dental care spending.[56] However, these findings from privately insured adults may not generalize to adults with public insurance, who tend to have less resources, limited access to care, and worse oral health. To date, only one study has focused on evaluating the effect of preventive dental care on dental treatment service use and expenditures among adult Medicaid beneficiaries.[57] In this 2018 study, investigators found preventive dental care was associated with a higher likelihood of future non-preventive dental visits, but lower overall dental expenditures among a sample of Medicaid-enrolled adults with chronic conditions in California.[57] This study, however, as well as the previously described analyses from private insurers, did not control for unobserved characteristics among adults that may affect health behaviors and outcomes, such as family history, oral health literacy and health consciousness. Without accounting for these unobserved individual characteristics, which influence an individual's propensity to receive dental care, the relationship between preventive dental care and subsequent oral health outcomes may be spurious.

Of note, private dental and health insurers, such as Cigna and Aetna, have also reported lower medical expenditures, fewer emergency room visits, and fewer in-patient hospital admissions among adults who receive regular dental services than those that do not.[55,58] The exact mechanisms as to why regular dental care is associated with medical outcomes including medical expenditures is not well understood. Poor oral health, and in particular gum disease, is associated with several chronic diseases and conditions, such as cardiovascular disease, chronic kidney disease, diabetes, obesity, and rheumatoid arthritis, to name a few.[59–66] Poor oral health is also associated with worse mental and

emotional health,[59,60] pain,[7,8] and reduced quality of life.[14,15,17,67] Some suggest that treatment of common oral diseases, such as gum disease and tooth loss, may positively affect overall health and ultimately reduce medical expenditures, through improvements in physical, psychological and social well-being.[68,69]

Only a limited number of studies have explored whether dental services reduce overall health care costs.[52,70–74] All of these studies have been unable to control for important confounding factors between receipt of dental care and medical care expenditures.[52] For instance, those who are more sick are more likely to have higher medical care expenditures and may also be too ill to prioritize or physically travel to receive dental care. Other confounding factors such as an individual's health literacy, their hygiene habits and their level of health consciousness may make relationships between regular dental care and medical outcomes spurious. Further, the majority of previous studies have analyzed privately insured populations limiting the generalizability of findings. Overall, rigorous research with greater internal validity is needed to determine whether use of adult dental care (specifically preventive dental care) reduces medical expenditures, especially among populations that disproportionately suffer from poor oral health and other chronic conditions.

Overview of dissertation

This purpose of this dissertation is to examine the factors and outcomes associated with use of dental care among Medicaid-enrolled adults. All three studies will rely on enrollment and claims data from the Indiana Family Social Services Administration, the superagency which administers Medicaid. Study 1 examines factors associated with dental care use among Medicaid-enrolled adults. Study 2 examines the effect of

preventive dental visits on non-preventive dental visits and dental expenditures among Medicaid-enrolled adults. Study 3 examines the relationship between preventive dental visits and overall medical expenditures among Medicaid-enrolled adults.

Study 1 considers select factors which may affect use of adult dental care beyond Medicaid dental benefits. Previous studies on Medicaid-enrolled adults' use of dental care have been at the national level and have not examined relevant individual- and community-level correlates of adult dental care use. For instance, no previous study has specifically examined the supply of Medicaid-participating dental providers available to enrollees at a community-level or adults' travel distance to the nearest Medicaid dental provider. Using a pooled cross-sectional design, this study builds on previous research by examining more granular correlates of dental care use at the individual- and county-level among low-income adults with Medicaid dental benefits.

Study 2 uses a robust econometric technique to examine whether and to what extent adult preventive dental services reduces subsequent non-preventive dental visits, non-preventive expenditures, and total dental expenditures among a Medicaid-enrolled adult population. Previous research is limited and has been unable to control for important adult characteristics which influence an individual's propensity to regularly use preventive dental care. This study expands current knowledge by using an individual fixed effects model to control for time-invariant unobserved characteristics that affect receipt of dental care services and confound the relationship between preventive dental care and oral health outcomes.

Study 3 uses an instrumental variable estimation method to determine the relationship between preventive dental visits and overall medical expenditures among

Medicaid-enrolled adults. Previous studies have failed to control for key confounding factors that may make relationships between dental care and medical outcomes spurious, such as individual health-seeking behaviors and health consciousness. This study expands upon previous research by using an approach with greater internal validity to mitigate bias resulting from unobserved factors which are correlated with both receipt of dental care and medical care costs.

Overall this dissertation considers factors and outcomes that are associated with use of dental care among an underexplored population of lower-income adults. Given common state budget constraints that place adult public dental insurance programs at risk, it is important to quantify barriers beyond coverage that impact access and determine the individual and economic value of dental care use among adult Medicaid enrollees. This dissertation provides evidence that can inform the design and sustainability of state and local polices intended to reduce disparities, increase dental care utilization, and improve oral health along low-income adults.

CHAPTER TWO

FACTORS ASSOCIATED WITH DENTAL CARE USE AMONG MEDICAID-ENROLLED ADULTS

Introduction

Low-income adults face considerable challenges in accessing dental care, with cost of care being a primary barrier.[1–3,20] They are substantially less likely to use dental care and more likely to have poor oral health than adults at other income levels.[3,31,46,75,76] Currently, thirty-five states provide dental benefits for low-income adults through Medicaid, which is associated with greater dental care utilization, lower rates of untreated caries, and fewer non-traumatic emergency department dental visits.[25,46,75,77,78] However, barriers to care remain, as even with benefits, Medicaid-enrolled adults are half as likely to visit a dentist annually than privately-insured adults.[43,44,79]

Cost is not the only barrier to dental care for adults, and simply providing coverage may not practically expand access, increase use of dental care, or improve oral health. For instance, individual-level factors such as age, sex, race and ethnicity are associated with dental care utilization.[80,81] Furthermore, utilization is associated with location, including travel distance to nearest provider and area-level measures of the number of dental providers.[26,82,83] Over 56 million Americans live in dental health professional shortage areas, and less than half of all dentists participate in Medicaid.[27,28,31,84,85] The number of dentists and their participation in Medicaid is known to affect children's use of dental care,[36–42] but whether these factors are associated with Medicaid-enrolled adults is not as well-known. Previous analyses of dental care use among Medicaid-enrolled adults have all been conducted at the national level and lack

community-level geographic data and individual-level factors.[28,43,79] For instance, to our knowledge, no study has examined how distance to a dental provider is related to dental care utilization among Medicaid-enrolled adults. Given that low-income adults are disproportionately burdened by dental disease, it is necessary to examine heterogeneity of dental care use in this high-risk population in order to better target interventions aimed at increasing access and improving oral health.

This study measured the association of select individual- and county-level characteristics with overall dental care use, preventive dental care use, and non-preventive dental care use among Medicaid-enrolled adults with dental benefits. We used measures representing individual-level characteristics (including distance to nearest dentist) and county-level factors (including supply of Medicaid-participating dentists) to facilitate a greater understanding of correlates of dental care use among low-income adults. Our findings may inform interventions focused on reducing oral health disparities and improving oral and overall health among vulnerable populations.

Methods

Data and Sample

Data for this pooled cross-sectional study were derived from administrative data, including enrollment and claims data from the Indiana Family and Social Services Administration Office of Medicaid Policy and Planning (OMPP). To meet our inclusion criteria, the adult was required to be non-elderly (between the ages of 19 and 64) and continuously enrolled in Indiana's Healthy Indiana Plan (HIP) Plus program or the HIP State Plan Plus program for at least twelve months. Indiana expanded Medicaid eligibility to non-disabled adults aged 19 to 64 with incomes up to 138% of the Federal Poverty

Level (FPL) using a Section 1115 waiver beginning February 1, 2015. Dental coverage is included provided enrollees make fixed monthly payments (between $1 to $20 depending on income) into a health savings account.[86,87] Individuals were excluded from our study if they failed to make payments as this resulted in reduced benefits (including dental coverage) or lock-out from the program for 6 months.[87] Dental benefits provided by the HIP Plus program include routine dental care, radiographs, and some minor and major restorative services free of charge to enrolled adults. Similarly, the HIP State Plan Plus program provides dental benefits (although more enhanced and comprehensive than HIP Plus) for eligible parents, caretakers, low-income 19- and 20-year old dependents, and those determined to be "medically frail" by the state.[90] Except in the case of nonemergency visits to the emergency department, the HIP Plus and State Plan Plus programs have no point-of-service cost sharing.[86,87]

County-level data from the Health Resources and Service Administration's Area Health Resources File (AHRF)[90] were used to link economic and population factors to each enrollee in the sample, based on the county where the enrollee resided. Rural-Urban Commuting Area (RUCA) codes (measures of population density, urbanization, and daily commuting) were used to characterize the rurality of the county where the enrollee resided.[91]

The total number of unique individuals enrolled in HIP Plus or State Plan Plus insurance programs during the study time period (February 1, 2015 to December 31, 2018) was 610,605. Of these enrollees, 242,022 (39.6%) had less than 12 months of continuous enrollment, and thus they were excluded as they did not meet our inclusion criteria.

Variables

Dependent variables

We used three binary dependent variables to measure 1) any dental visits (ADV), 2) any preventive dental visits (PDV), and 3) any non-preventive dental visit (NPV) occurring in a twelve-month continuous enrollment time period. Specifically, ADV was defined as the presence of a dental claim with Common Dental Procedure (CDT) codes D0000 to D9999 in a twelve-month enrollment period. Further, following the Healthcare Effectiveness Data and Information Set Definition, any PDV was defined as the presence of any dental claim with CDT codes D0120, D0150, or D1000 to D1999 in a twelve-month period of enrollment and the absence of CDT codes D2000-D9999.[51,92] The presence of a dental claim with CDT codes D2000-D9999 during a twelve-month enrollment period with the absence of CDT codes D1000-D1999 was defined as a NPV.

Individual-level predictors

Age, sex (male, female), race/ethnicity (white, Black, Hispanic, other), marital status (married, never married, divorced, widowed/unknown), living arrangement (lives in a home, homeless, communal living facility, unknown), family size (1, 2, 3, 4, 5 or more, and unknown), claim-type (fee-for-service (FFS), managed care organization (MCO)), calendar year, the period of enrollment, and the total number of months continuously enrolled, were included as independent variables and derived from Medicaid enrollment and claims data. Age and the number of months enrolled were also considered as categorical variables. We grouped age into the following categories: 19 to 24 years old, 25 to 34 years old, 35 to 44 years old, 45 to 54 years old and 55 to 64 years old. To categorize the number of months enrolled, we divided the distribution of this

continuous variable into equal quartiles, and then made adjustments to each group to fit within whole numbers (12 to 19 months, 20 to 28 months, 29 to 40 months, 41 to 47 months).

For each enrollee's twelve-month enrollment period, we calculated the distance between the enrollee's home address and the nearest practice address of a Medicaid-participating general dentist. In cases where an enrollee had multiple addresses, we designated the modal address as the primary for that enrollment period. We retrieved the addresses of all general dentists who submitted a dental claim in the study period (n=2,682) from the OMPP's administrative provider data. Providers not classified as general dentists, namely endodontists, periodontists, orthodontists, and oral surgeons, were not included (n=312). A small number of general dentists who submitted Medicaid dental claims had missing practice address information (n=275). These addresses were obtained using the provider's National Provider Identifier (NPI) and the Centers for Medicare and Medicaid Services' National Plan and Provider Enumeration System's NPI Registry.[93] Next, we estimated the straight-line distance (in miles) between each enrollee's geocoded primary home address and each Medicaid-participating general dentist's geocoded practice location. The shortest distance was determined and categorized into five groups based on the distribution of the variable and cut-off points designed for ease of interpretation (less than 0.5 mile; between 0.5 and 1 miles; between 1 and 2 miles; between 2 and 5 miles; and more than 5 miles). Enrollees who had geocoded home addresses outside of Indiana were excluded from the final analytic sample (n=9,878).

Using enrollee medical claims submitted during the study time period, we also determined whether enrollees had an annual well visit (yes, no) with a physician. Similar to previous research, we defined an annual well visit as the presence of a medical claim with Current Procedural Terminology Codes 99385, 99386, 99387, 99395, 99396, and 99397.[74]

County-level predictors

For each twelve-month period of enrollment, we obtained the county and census block of each enrollee's geocoded primary home address. We linked annual county-level factors from AHRF to each enrollee, including dental health professional shortage area (DHPSA) designation[2], primary care health professional shortage area (HPSA) designation[3], the number unemployed, the number of Federally Qualified Health Centers (FQHCs), the total population, the number of non-Hispanic whites, the number of dentists with an NPI, the number of dentists with an active license, and the percentage of people between the ages of 18-64 who are at 138% of the FPL. DHPSA and HPSA designation were converted into binary measures (full or partial shortage areas versus no shortage areas). The number of dentists with an NPI, and the number of dentists with an active license, were measures we divided by the total county population and expressed as the number of dentists per 5000 population. The number of dentists with active licenses

[2] A county is designated as a DHPSA if the area has a population to full-time equivalent dentist ratio of at least 5,000:1 (or 4,000:1 in unusually high need areas) or if dental professionals in contiguous counties are over-utilized, too far in distance or inaccessible to the county population under consideration.[94]

[3] A county is designated as a HPSA if the area has a population to full-time equivalent primary care doctor ratio of at least 3,500:1 (or 3,000:1 in unusually high need areas) or if primary care professionals in contiguous counties are over-utilized, too far in distance or inaccessible to the county population under consideration.[94]

per 5000 population was categorized into 4 groups (0-1, 2, 3, and 4 or more) Further, we linked RUCA codes to our primary dataset which were conflated into the following categories: urban, large rural, small rural, and isolated.

Using dental claims, we also calculated the annual county-level number of HIP Plus and State Plan Plus enrollees, number of Medicaid-participating dentists per 1000 enrollees, and the number of Medicaid-participating dentists in an FQHC. We categorized the number of Medicaid-participating dentists per 1000 enrollees into five groups (0-1, 2, 3, 4, and 5 or more dentists). Finally, we created a binary measure to indicate whether the county had at least one Medicaid-participating dentist working in an FQHC (yes, no).

Analysis

We characterized enrollees included in our study using means and frequencies. We used Chi-square and z-test statistics to measure associations between adults' use of dental care and individual- and county-level factors. Based on conceptual theory derived from the Behavioral Model of Health Services Use,[96,97] the strength of bivariate associations, and collinearity between certain independent variables, we reduced the set of possible explanatory variables from the full list previously described for our final parsimonious model. The final parsimonious model included the following individual-level factors: sex, race/ethnicity, living arrangement, age, calendar year, claim type, total months of enrollment, distance to the nearest dentist, family size, period of enrollment, and annual well visit. Further, the following county-level factors were also included in the final model: RUCA designation, DHPSA designation, HPSA designation, number of dentists with an active license per 5,000 population, number of Medicaid-participating

dentists per 1,000 HIP Plus and State Plan Plus enrollees, and whether the county had an FQHC with dental providers.

Because our dataset contained repeated observations and individuals nested within counties, we used multi-level regression models to assess the effect of individual- and county-level factors on dental care use. This method allows us to estimate the amount of variance in dental care use attributable to the enrollee and attributable to the county where the enrollee resides. We tested multiple model specifications to determine whether there was a significant amount of variation explainable at the individual- and county-level and for robustness checks. We consistently found the amount of total variation explained at the county-level was small (~0.05%). Therefore, a two-level hierarchical model accounting for repeated observations was selected as the most parsimonious and statistically efficient modelling strategy.

We calculated the intraclass correlation coefficient for the null multi-level model (with no covariates) and the final parsimonious model (with covariates) to estimate the amount of variance explained at the individual level by the model covariates. All estimates were reported with 95% confidence intervals. We also conducted sensitivity analyses (see Appendix A, Table A1) by evaluating a less restrictive sample of adults who were continuously enrolled for at least 11 months (383,911 adults providing 684,163 adult-year observations). We used SAS 9.2[96] software for data management and Stata SE version 17[97] software for all our statistical analyses.

Results

A total of 358,685 adults contributed 618,722 adult-year observations during the study period. HIP Plus and State Plan Plus adults were primarily white (73.5%), female

(65.0%), and continuously enrolled for an average length of 29 months. Approximately 40.1% (n=248,115) of enrollees had ADV in a given enrollment period, 28.8% (n=177,975) had a PDV, and 25.1% (n=155,290) had a NPV. Table 1 presents descriptive statistics and bivariate associations between individual-level factors and ADV, any PDV, and any NPV during a twelve-month continuous enrollment period. Table 2 presents descriptive statistics and bivariate associations between county-level factors and ADV, any PDV, and any NPV during a twelve-month continuous enrollment period.

Prior to controlling for individual-level factors and county-level factors, we estimated that 35.1% of the total variation in ADVs was unexplained by within individual differences. The final parsimonious model (presented in Table 3) reduced the amount of unexplained variation by 1.5 percentage points to 33.6%. Similarly, 33.0% of the total variation in PDVs was unexplained at the individual level in the empty model, which was reduced by 1.7 percentage points to 31.3% in the adjusted model. Less total variation in NPVs was unexplained by within individual differences (19.7%). Our model reduced the total variation in NPVs explained at the individual-level to 19.1% in the adjusted model (0.6 percentage point reduction).

Several individual-level factors were associated with a greater likelihood of having ADV in a twelve-month period (see Table 3). These characteristics included having an annual well visit (8.2 percentage points (pps); 95% CI 7.9 to 8.5) and being female (5.8 pps; 95% CI 5.5 to 6.1). Both Blacks (2.9 pps; 95% CI 2.5 to 3.3) and Hispanics (1.7 pps; 95% CI 1.1 to 2.3) had a greater likelihood of having ADV than whites. Individual-level factors associated with a lower likelihood of having ADV include further distance to the nearest dentist (-1.2 pps; 95% CI -1.7 to -0.7) and age

above 34 (-2.0 pps; 95% CI -2.5 to -1.5). Additionally, those who were never married (-1.1 pps; 95% CI -1.4 to -0.7) or widowed (-3.8 pps; 95% CI -4.5 to -3.1) were less likely to have ADV than those who were married.

At the county-level (see Table 3), having 2 or more Medicaid-participating dentists per 1000 enrollees was associated with a greater likelihood an enrollee would have ADV within a year. Having a dental provider in an FQHC (1.2 pps; 95% CI 0.8 to 1.6) was also associated with a greater likelihood an enrollee had ADV. In contrast, county-level factors found to be associated with a lower likelihood of an enrollee having ADV included large rural area RUCA designation (-0.8 pps; 95% CI -1.2 to -0.3) and DHPSA designation (-0.7 pps; 95% CI -1.2 to -0.3).

Findings were similar when the dependent variable was any PDV or any NPV in a given year, although the effect sizes were attenuated (Table 3). For instance, having an annual well visit was associated with a 9.0 pps greater likelihood (95% CI 8.7 to 9.2) of having a PDV and 4.8 pps greater likelihood (95% CI 4.5 to 5.0) of having a NPV. Compared to those living in a home, those living in a communal facility or those who were homeless were less likely of having any PDV (-3.4 pps, 95% CI -4.8 to -2.1; -1.7 pps, 95% CI -2.4 to -1.0, respectively). Further, being Black was associated with a greater likelihood of having a PDV (1.7 pps, 95% CI 1.3 to 2.1) but not associated with a greater likelihood having a NPV than whites. While Hispanics had a greater likelihood of having a PDV (3.0 pps, 95% CI 2.4 to 3.6), they had a lower likelihood of having a NPV (-1.2 pps, 95% CI -1.7 to -0.7) compared to whites.

Table 1: Means, frequencies, and bivariate associations between individual-level factors and any dental visit (ADV), any preventive dental visit (PDV) and any non-preventive visit (NPV) among Indiana Medicaid-enrolled adults[a]

	Total enrollees N=618,772	**ADV** n=248,115 (40.1%)	p-value	**PDV** n=177,975 (28.8%)	p-value	**NPV** n=155,290 (25.1%)	p-value
Individual-level Factors							
Annual well visit							
Yes	160,365 (25.9)	78,433 (31.6)	<0.001	61,226 (34.4)	<0.001	47,521 (30.6)	<0.001
No	458,407 (74.1)	169,682 (68.4)		116,749 (65.6)		107,769 (69.4)	
Sex			<0.001		<0.001		<0.001
Female	402,001 (65.0)	173,021 (69.7)		126,572 (71.1)		107,616 (69.3)	
Male	216,771 (35.0)	75,094 (30.3)		51,403 (28.9)		47,674 (30.7)	
Race/Ethnicity			<0.001		<0.001		<0.001
White	455,058 (73.5)	179,885 (72.5)		128,704 (72.3)		115,020 (74.1)	
Black	82,154 (13.3)	35,191 (14.2)		24,816 (13.9)		20,733 (13.3)	
Hispanic	33,253 (5.4)	14,108 (5.7)		10,827 (6.1)		8,075 (5.2)	
Other	48,307 (7.8)	18,931 (7.6)		13,628 (7.7)		11,462 (7.4)	
Marital Status			<0.001		0.044		<0.001
Married	153,502 (24.8)	61,197 (24.7)		44,727 (25.1)		37,877 (24.4)	
Never married	297,922 (48.2)	119,217 (48.0)		85,842 (48.2)		73,560 (47.4)	
Divorced	133,964 (21.6)	55,989 (22.6)		38,939 (21.9)		36,560 (23.5)	
Widowed/Unknown	33,384 (5.4)	11,712 (4.7)		8,467 (4.8)		7,293 (4.7)	
Living arrangement			<0.001		<0.001		<0.001
Lives in a home	570,292 (92.2)	230,412 (92.9)		165,852 (93.2)		144,154 (92.8)	
Communal living facility	5,467 (0.9)	1,932 (0.8)		1,195 (0.7)		1,291 (0.8)	
Homeless	20,172 (3.2)	7,596 (3.0)		5,126 (2.9)		4,724 (3.1)	
Unknown	22,841 (3.7)	8,175 (3.3)		5,802 (3.2)		5,121 (3.3)	
Family size			<0.001		<0.001		<0.001
1	255,985 (41.4)	97,766 (39.4)		68,857 (38.7)		61,527 (39.6)	
2	133,425 (21.5)	54,045 (21.8)		39,104 (22.0)		33,835 (21.8)	
3	96,087 (15.5)	40,563 (16.3)		29,447 (16.5)		25,517 (16.5)	

4	68,501 (11.1)	28,942 (11.7)		21,135 (11.9)		18,028 (11.6)	
5 or more	62,018 (10.0)	25,699 (10.4)		18,652 (10.5)		15,717 (10.1)	
unknown	2,756 (0.5)	1,100 (0.4)		780 (0.4)		666 (0.4)	
Age, mean (SD)	39.7 (12.5)	38.8 (12.2)	<0.001	38.7 (12.4)	<0.001	38.9 (12.0)	<0.001
Age categories (%)			<0.001		<0.001		<0.001
19-24	76,653 (12.9)	33,613 (13.5)		25,707 (14.4)		19,376 (12.5)	
25-34	162,374 (26.2)	69,620 (28.1)		48,834 (27.4)		44,671 (28.8)	
35-44	144,619 (23.4)	59,972 (24.2)		42,479 (23.9)		38,137 (24.5)	
45-54	134,770 (21.8)	51,746 (20.8)		36,382 (20.5)		32,794 (21.1)	
55-64	97,356 (15.7)	33,164 (13.4)		24,573 (13.8)		20,312 (13.1)	
Distance to nearest DDS[b] (miles), mean (SD)	2.15 (2.73)	2.09 (2.65)	<0.001	2.09 (2.64)	<0.001	2.12 (2.69)	<0.001
Distance to nearest DDS[b] (miles)			<0.001		<0.001		<0.001
<0.5 mile	143,419 (23.2)	58,076 (23.4)		41,032 (23.1)		36,454 (23.5)	
0.5 to 1.0 miles	172,529 (27.9)	70,141 (28.3)		50,013 (28.1)		43,602 (28.1)	
1.0 to 2.0 miles	128,092 (20.7)	51,877 (20.9)		37,796 (21.2)		31,980 (20.6)	
2.0 to 5.0 miles	87,645 (14.1)	35,007 (14.1)		25,605 (14.4)		21,972 (14.1)	
>5.0 miles	87,087 (14.1)	33,014 (13.3)		23,529 (13.2)		21,282 (13.7)	
Claim Type			<0.001		0.012		<0.001
FFS[c]	226,617 (36.6)	89,844 (36.2)		65,691 (36.9)		55,789 (35.9)	
MCO[d]	392,155 (63.4)	158,271 (63.8)		112,284 (63.1)		99,501 (64.1)	
Year Indicator			<0.001		<0.001		<0.001
2015	140,539 (22.7)	59,415 (24.0)		43,129 (24.2)		38,461(24.8)	
2016	186,381 (30.1)	75,989 (30.6)		54,133 (30.4)		48,030 (30.9)	
2017	200,405 (32.4)	77,755 (31.3)		55,739 (31.3)		47,671 (30.7)	
2018	91,447 (14.8)	34,956 (14.1)		24,974 (14.1)		21,128 (13.6)	
Months of Enrollment, mean (SD)	29.2 (11.9)	29.7 (11.9)	<0.001	30.0 (11.9)	<0.001	29.5 (11.9)	<0.001
Months of Enrollment			<0.001		<0.001		<0.001
12 to 19 months	165,110 (26.7)	63,477 (25.6)		44,101 (24.8)		40,314 (26.0)	
20 to 28 months	148,601 (24.0)	58,352 (23.5)		41,436 (23.3)		36,860 (23.7)	

29 to 40 months	156,439 (25.3)	63,326 (25.5)		45,659 (25.6)		39,593 (25.5)	
41 to 47 months	148,622 (24.0)	62,960 (25.4)		46,779 (26.3)		38,523 (24.8)	
Period of Enrollment			<0.001		0.885		<0.001
1	377,103 (60.9)	152,332 (61.4)		108,983 (61.3)		97,780 (63.0)	
2	167,660 (27.1)	66,183 (26.7)		47,222 (26.5)		40,364 (26.0)	
3	74,009 (12.0)	29,660 (11.9)		21,770 (12.2)		17,146 (11.0)	
Total years enrolled, mean (SD)	2.02 (0.8)	2.04 (0.8)	<0.001	2.06 (0.8)	<0.001	2.03 (0.8)	<0.001

[a] – Specific to Healthy Indiana Program (HIP) Plus and State Plan Plus enrollees with at least 12 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018 (N= 618,722 person-enrollment years)
[b] – Dentist (general practitioner)
[c] – Fee-for-service
[d] – Managed care organization

Table 2: Means, frequencies, and bivariate associations between county-level factors and any dental visit (ADV), any preventive dental visit (PDV) and any non-preventive visit (NPV) among Indiana Medicaid-enrolled adults[a]

	Total enrollees N=618,772	**ADV** n=248,115 (40.1%)	p-value	**PDV** n=177,975 (28.8%)	p-value	**NPV** n=155,290 (25.1%)	p-value
County-level Factors							
RUCA designation[b]			<0.001		<0.001		0.053
Urban	483,513 (78.2)	195,684 (78.9)		140,953 (79.2)		121,021 (77.9)	
Large rural	86,168 (13.9)	33,157 (13.4)		23,408 (13.2)		21,770 (14.0)	
Small rural	31,563 (5.1)	12,531 (5.1)		8,947 (5.0)		8,160 (5.3)	
Isolated	17,416 (2.8)	6,695 (2.7)		4,667 (2.6)		4,339 (2.8)	
DHPSA designation[c]			<0.001		<0.001		<0.001
No shortage	222,113 (35.9)	88,020 (35.5)		62,509 (35.1)		56,973 (36.7)	
Full or partial shortage	396,659 (64.1)	160,095 (64.5)		115,466 (64.9)		98,317 (63.3)	
HPSA designation[d]			0.877		0.014		0.597
No shortage	96,287 (15.6)	38,584 (15.5)		28,063 (15.8)		24,236 (15.6)	
Full or partial shortage	522,485 (84.4)	209,531 (84.5)		149,912 (84.2)		131,054 (84.4)	
Number of FQHCs[e], mean (SD)	12.9 (20.3)	13.1 (20.4)	<0.001	12.9 (20.1)	0.908	12.6 (20.1)	<0.001
Number of Medicaid-participating DDS[f] at FQHCs[e], mean (SD)	1.69 (2.23)	1.73 (2.24)	<0.001	1.72 (2.22)	<0.001	1.66 (2.20)	<0.001
Medicaid-participating DDS[f] at FQHCs[e]			<0.001		<0.001		0.006
No	297,178 (48.0)	117,036 (47.2)		83,489 (46.9)		75,096 (48.4)	
Yes	321,594 (52.0)	131,079 (52.8)		94,486 (53.1)		80,194 (51.6)	
Number of Medicaid-participating DDS[f] per 1,000 enrollees, mean (SD)	5.12 (5.41)	5.22 (5.48)	<0.001	5.14 (5.42)	0.081	5.11 (5.39)	0.335
Number of Medicaid-participating DDS[f] per 1,000 enrollees			<0.001		<0.001		<0.001
0-1	21,776 (3.5)	7,886 (3.2)		5,631 (3.2)		5,003 (3.2)	
2	103,314 (16.7)	39,852 (16.1)		29,156 (16.4)		25,294 (16.3)	
3	220,959 (35.7)	87,850 (35.4)		63,320 (35.6)		55,015 (35.4)	
4	115,479 (18.7)	47,710 (19.2)		33,884 (19.0)		30,673 (19.8)	
5 or more	157,244 (25.4)	64,817 (26.1)		45,984 (25.8)		39,305 (25.3)	

Number of enrollees, mean (SD)	18,037.8 (22,560.8)	18,248.1 (22,586.4)	<0.001	18,062.9 (22,291.8)	0.624	17,544.6 (22,242.0)	<0.001
Persons white non-Hispanic, mean (SD)	90,992.7 (84,329.8)	92,277.0 (84,676.5)	<0.001	92,203.1 (83,597.4)	<0.001	89,254.0	<0.001
Persons unemployed, mean (SD)	6338.5 (7178.0)	6484.6 (7257.0)	<0.001	6458.7 (7181.4)	<0.001	6262.0 (7184.5)	<0.001
Dentists with a NPI[g] per 5,000 population, mean (SD)	2.74 (1.0)	2.75 (1.0)	<0.001	2.75 (0.99)	<0.001	2.72 (1.0)	<0.001
Dentists with an active license per 5,000 population, mean (SD)	2.36 (0.8)	2.38 (0.8)	<0.001	2.38 (0.8)	<0.001	2.35 (0.8)	<0.001
Dentists with an active license per 5,000 population			<0.001		<0.001		0.148
0-1	38,625 (6.2)	14,800 (6.0)		10,304 (5.8)		9,597 (6.2)	
2	156,701 (25.3)	61,593 (24.8)		43,872 (24.6)		39,613 (25.5)	
3	277,925 (44.9)	111,739 (45.0)		81,433 (45.8)		69,923 (45.0)	
4 or more	145,521 (23.5)	59,983 (24.2)		42,366 (23.8)		36,157 (23.3)	
Persons ages 18-64 at 138% FPL[h], mean (SD)	38,729.0 (48,482.7)	39,401.9 (48,845.9)	<0.001	39,016.5 (48,208.5)	0.010	37,992.6 (48,198.9)	<0.001
Total population (SD)	293,533 (322,815.9)	298,180.4 (324,373.1)	<0.001	296,924.3 (320,139)	<0.001	287,280.9 (320,659.8)	<0.001

[a] – Specific to Healthy Indiana Program (HIP) Plus and State Plan Plus enrollees with at least 12 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018. (N= 618,722 person-enrollment years)

[b] – Rural-Urban Commuting Areas as defined by the U.S. Department of Agriculture Economic Research Service

[c] – Dental health professional shortage area as defined within Area Health Resource File from the U.S. Health Resources and Services Administration

[d] – Primary care health professional shortage area as defined within Area Health Resource File from the U.S. Health Resources and Services Administration

[e] – Federally Qualified Health Center

[f] – Dentist (general practitioner)

[g] – National Provider Identifier

[h] – Federal poverty level

Table 3: Results (partial effects) of multi-level linear probability models of receipt of any dental visit (ADV), any preventive dental visit (PDV) and any non-preventive visit (NPV) among Indiana Medicaid-enrolled adults[a]

	ADV			PDV			NPV		
	Partial effects	95% CI	p-value	Partial effects	95% CI	p-value	Partial effects	95% CI	p-value
Individual-level factors									
Annual well visit	0.082	(0.079, 0.085)	<0.001	0.0899	(0.087, 0.092)	<0.001	0.0477	(0.045, 0.050)	<0.001
Sex									
Male	ref	ref	ref	ref	ref	ref	ref	ref	ref
Female	0.058	(0.055, 0.061)	<0.001	0.0526	(0.050, 0.055)	<0.001	0.0324	(0.030, 0.035)	<0.001
Race/ethnicity									
White	ref	ref	ref	ref	ref	ref	ref	ref	ref
Black	0.029	(0.025, 0.033)	<0.001	0.017	(0.013, 0.021)	<0.001	0.001	(-0.003, 0.005)	0.672
Hispanic	0.017	(0.011, 0.023)	<0.001	0.030	(0.024, 0.036)	<0.001	-0.012	(-0.017, -0.007)	<0.001
Other	-0.004	(-0.009, 0.001)	0.141	-0.001	(-0.006, 0.003)	0.619	-0.013	(-0.017, -0.008)	<0.001
Marital Status									
Married	ref	ref	ref	ref	ref	ref	ref	ref	ref
Never married	-0.011	(-0.014, -0.007)	<0.001	-0.011	(-0.015, -0.007)	<0.001	-0.004	(-0.008, -0.001)	0.013
Divorced	0.017	(0.012, 0.021)	<0.001	-0.002	(-0.006, 0.002)	0.245	0.022	(0.018, 0.026)	<0.001
Widowed/Unknown	-0.038	(-0.045, -0.031)	<0.001	-0.031	(-0.037, -0.024)	<0.001	0.021	(-0.027, -0.015)	<0.001
Living arrangement									
Lives in home	ref	ref	ref	ref	ref	ref	ref	ref	ref
Communal living facility	-0.014	(-0.028, -0.001)	0.063	-0.034	(-0.048, -0.021)	<0.001	0.001	(-0.011, 0.013)	0.862
Homeless	-0.007	(-0.015, 0.001)	0.089	-0.017	(-0.024, -0.010)	<0.001	-0.006	(-0.013, 0.001)	0.064
Unknown	-0.014	(-0.021, -0.007)	<0.001	0.006	(-0.012, 0.001)	0.093	-0.013	(-0.019, -0.007)	<0.001
Family size									
1	ref	ref	ref	ref	ref	ref	ref	ref	ref
2	0.007	(0.003, 0.010)	0.001	0.007	(0.004, 0.011)	<0.001	0.004	(0.001, 0.007)	0.036
3	0.007	(0.003, 0.011)	0.001	0.010	(0.006, 0.014)	<0.001	0.004	(0.001, 0.008)	0.019
4	0.006	(0.001, 0.011)	0.020	0.011	(0.007, 0.016)	<0.001	0.001	(-0.003, 0.005)	0.670
5 or more	0.001	(-0.004, 0.006)	0.724	0.007	(0.002, 0.012)	0.008	-0.007	(-0.011, -0.002)	0.004
Unknown	-0.005	(-0.022, 0.013)	0.607	-0.003	(-0.019, 0.014)	0.766	-0.008	(-0.024, 0.008)	0.342

Age									
19-24 years old	ref	ref	ref	ref	ref	ref	ref	ref	ref
25-34 years old	-0.003	(-0.008, 0.002)	0.194	-0.029	(-0.033, -0.025)	<0.001	0.025	(0.021, 0.029)	<0.001
35-44 years old	-0.020	(-0.025, -0.015)	<0.001	-0.037	(-0.042, -0.033)	<0.001	0.013	(0.009, 0.017)	<0.001
45-54 years old	-0.048	(-0.053, -0.043)	<0.001	-0.057	(-0.061, -0.052)	<0.001	-0.007	(-0.012, -0.003)	0.001
55-64 years old	-0.082	(-0.088, -0.077)	<0.001	-0.068	(-0.073, -0.063)	<0.001	-0.037	(-0.042, -0.032)	<0.001
Months of Enrollment									
12 to 19 months	ref	ref	ref	ref	ref	ref	ref	ref	ref
20 to 28 months	0.020	(0.016, 0.023)	<0.001	0.023	(0.019, 0.026)	<0.001	0.014	(0.010 – 0.017)	<0.001
29 to 40 months	0.037	(0.033, 0.041)	<0.001	0.042	(0.038, 0.046)	<0.001	0.025	(0.021, 0.029)	<0.001
41 to 47 months	0.054	(0.049, 0.059)	<0.001	0.065	(0.060, 0.069)	<0.001	0.030	(0.025, 0.034)	<0.001
Period of enrollment									
1	ref	ref	ref	ref	ref	ref	ref	ref	ref
2	-0.017	(-0.020,-0.014)	<0.001	-0.022	(-0.025, -0.019)	<0.001	-0.024	(-0.027, -0.021)	<0.001
3	-0.014	(-0.019, -0.009)	<0.001	-0.020	(-0.025, -0.015)	<0.001	-0.031	(-0.035, -0.026)	<0.001
Year									
2015	ref	ref	ref	ref	ref	ref	ref	ref	ref
2016	-0.001	(-0.004, 0.003)	0.675	-0.001	(-0.004, 0.002)	0.489	-0.002	(-0.005, 0.001)	0.282
2017	-0.017	(-0.021, -0.013)	<0.001	-0.001	(-0.014, -0.006)	<0.001	-0.016	(-0.020, -0.012)	<0.001
2018	-0.015	(-0.020, -0.010)	<0.001	-0.006	(-0.010, -0.001)	0.018	-0.018	(-0.022, -0.013)	<0.001
Claim type									
FFS[b]	ref	ref	ref	ref	ref	ref	ref	ref	ref
MCO[c]	0.005	(0.002, 0.008)	0.001	-0.004	(-0.006, -0.001)	0.002	0.006	(0.004, 0.009)	<0.001
Distance to nearest DDS[d]									
<0.5 miles	ref	ref	ref	ref	ref	ref	ref	ref	ref
0.5 – 1.0 miles	0.001	(-0.003, 0.005)	0.558	0.002	(-0.002, 0.005)	0.295	-0.001	(-0.004, 0.002)	0.631
1.0 – 2.0 miles	-0.001	(-0.004, 0.003)	0.827	0.005	(0.001, 0.009)	0.008	-0.005	(-0.008, -0.001)	0.009
2.0 – 5.0 miles	-0.001	(-0.006, 0.003)	0.613	0.006	(0.002, 0.010)	0.006	-0.006	(-0.009, -0.002)	0.007

>5.0 miles	-0.012	(-0.017, -0.007)	<0.001	-0.005	(-0.009, -0.001)	0.043	-0.010	(-0.015, -0.006)	<0.001
County-level factors									
RUCA designation[e]									
Urban	ref	ref	ref	ref	ref	ref	ref	ref	ref
Large Rural	-0.008	(-0.012, -0.003)	0.001	-0.007	(-0.011, -0.003)	0.002	0.001	(-0.003, 0.005)	0.653
Small Rural	0.004	(-0.003, 0.010)	0.300	0.004	(-0.003, 0.010)	0.264	0.009	(0.003, 0.014)	0.003
Isolated	-0.002	(-0.011, 0.007)	0.664	-0.006	(-0.014, 0.002)	0.162	0.003	(-0.005, 0.010)	0.466
Number Medicaid-participating dentists[d]/1,000 enrollees									
0-1	ref	ref	ref	ref	ref	ref	ref	ref	ref
2	0.011	(0.003, 0.019)	0.009	0.011	(0.004, 0.018)	0.003	0.011	(0.004, 0.018)	0.002
3	0.016	(0.008, 0.023)	<0.001	0.010	(0.003, 0.017)	0.008	0.011	(0.004, 0.018)	0.001
4	0.029	(0.021, 0.037)	<0.001	0.016	(0.009, 0.023)	<0.001	0.023	(0.016, 0.030)	<0.001
5 or more	0.026	(0.017, 0.034)	<0.001	0.016	(0.008, 0.024)	<0.001	0.015	(0.007, 0.023)	<0.001
Number of dentists with active license per 5,000 population									
0-1	ref	ref	ref	ref	ref	ref	ref	ref	ref
2	-0.003	(-0.008, 0.004)	0.430	0.003	(-0.002, 0.009)	0.265	-0.002	(-0.008, 0.003)	0.392
3	-0.006	(-0.012, 0.001)	0.099	0.005	(-0.001, 0.011)	0.101	-0.004	(-0.009, 0.002)	0.224
4 or more	-0.004	(-0.012, 0.004)	0.341	0.001	(-0.007, 0.008)	0.864	-0.007	(-0.014, 0.001)	0.053
Medicaid-participating DDS[d] at FQHC[f]									
No	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	0.012	(0.008, 0.016)	<0.001	0.011	(0.008, 0.015)	<0.001	0.009	(0.006, 0.013)	<0.001
DHPSA designation[g]									
No shortage	ref	ref	ref	ref	ref	ref	ref	ref	ref
Full or partial shortage	-0.007	(-0.012,-0.003)	0.001	0.001	(-0.004, 0.004)	0.976	-0.014	(-0.018, -0.011)	<0.001
HPSA designation[h]									
No shortage	ref	ref	ref	ref	ref	ref	ref	ref	ref
Full or partial shortage	0.001	(-0.004, 0.006)	0.674	-0.008	(-0.012, -0.003)	<0.001	0.007	(0.003, 0.011)	<0.001

ref = Reference category, omitted from model

[a] – Specific to Healthy Indiana Program (HIP) Plus and State Plan Plus enrollees with at least 12 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Fee-for-Service
[c] – Managed Care Organization
[d] – Dentist (general practitioner)
[e] – Rural-Urban Commuting Areas as defined by the US Department of Agriculture
[f] – Federally Qualified Health Center
[g] – Dental health professional shortage area as defined within Area Health Resource File from the US Health Resources and Services Administration
[h] – Primary care health professional shortage area as defined within Area Health Resource File from the US Health Resources and Services Administration

Discussion

This study sought to determine how various individual- and county-level factors are associated with overall dental care use, preventive dental care use, and non-preventive dental care use among a sample of Medicaid-enrolled adults. We found that less than half of enrollees (40.1%) received dental care during a yearly enrollment period and less than one-third had a PDV (28.8%), despite having preventive dental benefits. A number of correlates to dental care use were found to exist at both the individual- and county-level. Further, a substantial amount of variation (35.1%) in dental care utilization is due to factors within individuals as determined by the intraclass correlation coefficients, however our model covariates reduced the unexplained portion of this variation relatively little.

Among individual-level factors, the strongest predictor of an enrollee having ADV, any PDV, and any NPV was having an annual well visit. Previous research has demonstrated annual well visits to be associated with adults' use of other key preventive services such as vaccinations, tobacco cessation programs and cancer screenings.[98,99] Some hypothesize that annual well visits are predictive of preventive care-seeking behavior because of unobserved individual characteristics such as health consciousness and health beliefs. Adults who intrinsically value health care may be more likely to seek care and/or adhere to recommended routine dental care schedules. Our results lend support for these hypotheses since having an annual well visit was associated with a greater likelihood of PDVs (+9.0 pps) but less so for NPVs (+4.8 pps). Administrative claims lack data on individuals' health beliefs or their perceived need for care, thus we could not test these conjectures.

We observed other factors, such as race, sex, and marital status, to be important predictors of dental care use. Blacks and Hispanics were more likely than whites to have ADV during an annual enrollment period, and in particular PDVs. Previous studies have found these racial and ethnic groups to be significantly less likely to use dental care.[100,101] However, consistent with our findings, a study of Alabama Medicaid-enrolled children found Black children had greater self-reported use of dental care than whites.[102] Further, a study evaluating preventive dental use among a nationally representative sample of adults found that while racial/ethnic minorities have lower utilization of preventive dental care, these disparities are eliminated when accounting for certain enabling resources, namely income and insurance.[103] Across adults of all income levels, Blacks and Hispanics report greater difficulty in receiving dental care due to costs than whites.[104] Thus, previous evidence and our findings suggest alleviating cost barriers with dental coverage may be enough to increase dental care utilization for certain low-income racial and ethnic groups. However, we do not know whether and to what degree public dental insurance may have an effect on reducing racial disparities in oral health among low-income adults. Further, our findings show differences in the type of dental care received by race and ethnicity. While Hispanics and Blacks were more likely to have ADV than whites, our findings show this association to be driven by preventive dental care use specifically. Hispanics were less likely than whites to have any NPV and Blacks were not more or less likely than whites to have any NPV. We lack dental diagnosis data at the individual level, so we are unable to determine whether these differences are driven by lack of clinical need for non-preventive care or lack of additional resources and support to receive appropriate non-preventive care. We suggest more granular research into these

racial/ethnic differences in dental care use to better understand these gradations in care. Finally, other particularly vulnerable groups, such as those who are institutionalized or homeless, were significantly less likely to have any PDV. These findings emphasize the relevance of social determinants of health in understanding heterogeneity in dental care use.

Contrary to other evidence,[24,33,105] we found that the county-level dentist-to-population ratio was not a statistically significant predictor after controlling for other factors. However, prior research indicates a nuanced association, as a nationally representative sample of children found state-level dentist-to-population ratio was a significant predictor of annual dental visits, but not when the model was specific to Medicaid-insured children.[36] Similar to studies of Medicaid-enrolled children,[37,39] we observed the supply of Medicaid-participating dentists associated with increased adult dental care use. Thus, simply measuring dentist-to-population ratio at the county- or state-level may be an imprecise measure of access for Medicaid-insured adults, as these individuals not only need to find a dentist, but one that accepts their coverage plan and can schedule an appointment in a timely manner.[90,106,107] Policy interventions aimed at increasing provider density, such as state and federal loan forgiveness programs,[108] may not lead to instant or substantial improvements in access for Medicaid-enrolled adults. Further, our findings suggest policymakers and researchers evaluating Medicaid programs should be careful to consider detailed measures of supply relative to the population they are studying.

In addition to provider supply measures, we found enrollees residing in counties designated as large rural areas were significantly less likely to have a ADV and any PDV

than enrollees residing in urban areas. Likewise, an enrollee's home-to-nearest provider distance was negatively associated with ADV, and in particular any NPV, especially for those living more than 5 miles away from a Medicaid-participating dentist. Farther travel distance has also been found to be a barrier to dental care use among Medicaid-enrolled children.[37,38] However, caution should be taken when considering county-level findings since we lack information on other important dental market factors, such as the number of people with private dental insurance or the number of patients each dentist treats in a given year. Since we were unable to account for other supply and demand factors in dental markets, our study can only generate hypotheses on these matters. Nevertheless, our findings may inform oral health workforce recruitment efforts in geographic areas with low resources.

Ultimately, a considerable amount of variation in use of dental care remains unexplained at the individual-level. Other factors, such as perceived need or clinical need for dental care, oral health knowledge, and beliefs, may be relevant to explaining variation in dental care use among Medicaid-enrolled adults. Further, an enrollee's overall health may also influence receipt of care. For instance, adults with chronic conditions are more likely to have unmet dental needs.[109] It may be that the time, effort, and finances required to manage chronic conditions limit some adults from regularly using dental care, which in turn may lead to greater unmet need.[109] Since we did not measure these potential factors, more work is needed. Nevertheless, this study provides valuable insights into understanding correlates of dental care use among low-income adults with dental benefits.

Despite noteworthy contributions, this study has limitations. First, county boundaries may not represent actual community dental markets. Second, we were unable to account for important individual-level factors, such as perceived need or clinical need for dental care, oral health beliefs, transportation barriers and travel costs, all of which are not measured in claims data. Third, we did not calculate the exact driving distance between an enrollee's address and the nearest dentists' address. Rather, we calculated the geodetic distance (straight-line) from one point of latitude and longitude to another point of latitude and longitude. While driving distance is a more precise representation of travel distance, research has demonstrated a high correlation between geodetic and driving distance calculations (R^2>0.9) resulting in an inconsequential amount of precision gained from analyses which use driving distance versus geodetic distance.[111] Fourth, Indiana's HIP programs utilize a section 1115 waiver, which may limit the generalizability of this study's findings to other state Medicaid programs with different benefit packages. Fifth, we lack address and practice data on Indiana-licensed dentists who do not participate in Medicaid but who affect market supply and demand for dental services in a given county. Finally, this study is cross-sectional and findings cannot be interpreted as causal relationships.

Conclusion

Despite coverage of dental benefits, low-income adults face barriers to dental care use, as evidenced by fewer than 30% who don't utilize preventive dental benefits on an annual basis. We identified a number of factors at the individual- and county-level that may play a role in whether low-income adults with Medicaid dental benefits receive annual dental care. Certain commonly used dentist supply measures may not capture the

specific geographic access barriers faced by those with public insurance and thus warrants careful consideration by researchers and policymakers when evaluating Medicaid-based programs.

CHAPTER THREE

DOES PREVENTIVE DENTAL CARE REDUCE NON-PREVENTIVE DENTAL VISITS AND EXPENDITURES AMONG MEDICAID-ENROLLED ADULTS?

Introduction

Poor oral health remains a significant public health challenge in the United States, particularly for vulnerable populations such as low-income adults.[1–3] Adverse outcomes such as caries,[7] periodontal disease (advanced gum disease),[113,114] and tooth loss[115] are associated with pain,[7,8] decreased chewing function,[9] negative social perceptions,[13] and reduced quality of life.[14–17,67] To maintain optimal oral health and avoid these poor outcomes, dental providers recommend routine preventive dental care.[40,45,54,55] The recommended frequency of preventive dental care is based on a dental provider's assessment of the individual's risk of (and from) oral disease.[121] For most adults, routine preventive dental care involves an oral exam and teeth cleaning twice a year, or once every six months.[122]

Routine dental care allows for early identification of oral diseases, preventive care, and/or tailored delivery of oral hygiene education, all of which may prevent more serious or extensive disease(s) and treatment(s).[40,46,47] However, evidence as to whether routine preventive dental care reduces non-preventive dental services and expenditures among adults is limited.[52,113,114] Some insurance payors have reported lower total dental expenditures and fewer dental emergencies among adult enrollees who receive preventive dental care than those who do not.[55,56,58] One study of a sample of Medicaid-enrolled adults with chronic diseases found preventive dental care was associated with an increased likelihood of future non-preventive dental visits, yet lower total dental

expenditures.[57] However, previous evidence has been subject to bias from unobserved characteristics such as individual oral health behaviors, habits, and beliefs which may confound the relationship between preventive dental care and future adverse oral health outcomes.

Given the high prevalence of poor oral health and unmet dental needs among low-income adults,[1,109] it is important to determine whether preventive dental care is effective against adverse oral health outcomes among this population, especially from a public insurance program perspective. States are not mandated to provide dental benefits for Medicaid-enrolled adults and as a result, coverage varies greatly across states ranging from no dental benefits whatsoever to "extensive" or comprehensive dental benefits.[75] Among national analyses, comprehensive or "extensive" Medicaid dental coverage is significantly associated with a greater likelihood of dental care use among low-income adults.[24,115] However, less than half of states provide comprehensive coverage of dental benefits for Medicaid-enrolled adults. Some states (n=16) provide "limited" Medicaid dental benefits to eligible low-income adults and cover diagnostic, preventive, and some minor restorative services, but overall cover less than one-sixth of all dental procedures.[75] Ultimately, little is understood about adult dental coverage variation across state Medicaid programs and how these programs relate to oral health outcomes and expenditures. Further, Medicaid dental benefits for low-income adults are often considered for cuts when state budgets are constrained.[43,53,116] Therefore, studies on the effectiveness of certain dental procedures among Medicaid populations are needed in order to inform state administrators and decision-makers who are trying to determine the optimal balance of covered services with limited budgetary resources.

This study examined whether and to what extent preventive dental visits are associated with non-preventive dental visits, non-preventive expenditures, and overall dental expenditures among a population of low-income adults enrolled in a state Medicaid program. Specifically, we examine the Healthy Indiana Plan (HIP) Plus program during the first four years of its implementation following Medicaid expansion. Effective February 1, 2015, Indiana expanded Medicaid eligibility using a section 1115 waiver. Under this waiver program, working non-disabled adults with incomes between 100-138% of the federal poverty level became newly eligible for "limited" Medicaid dental benefits. Our study design takes advantage of an econometric technique which controls for unobserved time-invariant characteristics that may confound the relationship between preventive dental care and non-preventive dental care and expenditures, including individuals' intrinsic care-seeking attitudes and their level of health consciousness. Findings from this study may provide insights to other states with Medicaid adult dental benefit packages or states considering adult Medicaid dental coverage plans. In addition, this study also contributes to evidence as to whether adult preventive dental care improves oral health outcomes, which has thus far been very limited.

Methods

This study used a repeated measures design with individual fixed effects (FE) to estimate the relationship between preventive dental visits (PDV) and non-preventive dental visits (NPV) and dental expenditures among Medicaid-enrolled adults with dental coverage.

Population and Data

Our primary data were administrative enrollment and claims data from Indiana's Family and Social Services Administration Office of Medicaid Policy and Planning. Our inclusion criteria required adults be continuously enrolled for 36 months in the HIP Plus program with no gap in coverage greater than one month between February 1, 2015 and December 31, 2018. Under the HIP Plus program, enrollees contribute a fixed monthly payment to a special savings account (referred to as a POWER account) which enrollees can use to help pay for their health care.[117] Monthly payments range from $1 to $20 depending on the enrollee's income.[117] As part of their coverage benefits, enrollees are able to receive two dental cleanings a year, up to four minor restorative services (e.g. fillings) every year, and one major restorative service (e.g. crown).[118,119] Our primary data was also supplemented with data from the Area Health Resources File which tracks whether a county is a dental health professional shortage area[4] (DHPSA).[94,120]

Dependent variables

For each twelve-month period of enrollment, we computed the following three outcomes: 1) number of NPVs, 2) annual expenditures for NPVs, and 3) total annual expenditures for all dental visits. We defined a NPV as the presence of a dental claim with Common Dental Procedure (CDT) codes for restorative (D2000-D2999), endodontic (D3000-D3999), periodontic (D4000-D4999), prosthodontic (D5000-D5999, D6200-D6999), oral and maxillofacial surgery (D7000-D7999) and/or all other non-preventive

[4] A county is designated as a dental health professional shortage area if the area has a population to full-time equivalent dentist ratio of at least 5,000:1 (or 4,000:1 in unusually high need areas) or if dental professionals in contiguous counties are over-utilized, too far in distance or inaccessible to the county population under consideration.[94]

(D6000-D6199, D8000-D9999) dental procedures. All dental services that were rendered by providers were counted, regardless of whether they were reimbursed or denied by Medicaid. Dental expenditures were calculated as the total amount paid by Medicaid for dental services over an annual enrollment period, adjusted for inflation using the 2019 Consumer Price Index.[121]

Main explanatory variable

Our main explanatory variable was a categorical variable which indicated the total number of preventive dental visits in the prior year (0, 1, 2, 3 or more). We defined a preventive dental visit as the presence of a dental claim with CDT codes (D1000-D1999) and the absence of CDT codes D2000-D9999 on the same claim.[122] To capture more long-term preventive care, we used the same definition of a preventive dental visit and created a categorical variable which indicated the total number of preventive dental visits in the prior two years (0, 1, 2, 3, 4 or more).

Analysis

We characterized the adults included in the study and calculated summary statistics for expenditures and the number of preventive, non-preventive, and total dental visits, conditional on the adult having any dental visit within a twelve-month enrollment period. Next, we analyzed two models for each of our outcomes of interest (number of NPVs, NPV expenditures, and total dental expenditures) using individual fixed effects linear regressions. First, we examined whether and to what extent prior year PDVs are associated with each outcome of interest. Next, we examined whether and to what extent PDVs in the previous two years are associated with each outcome of interest. Our empirical approach relies on variation in the number of preventive dental care visits and

each outcome of interest within the same adult over time. Individual fixed effects treat each adult as their own control, thus reducing bias from time-invariant individual characteristics, even if unobserved. By comparing each adult in years they received preventive dental care to themselves in years they did not receive preventive dental care, the model subsumes the effect of any time-invariant confounders at the individual level. While our approach mitigates bias from characteristics of the individual that remain constant over time, it does not address bias from time-varying characteristics. Thus, our regressions also includes controls for observable time-varying characteristics in our population, namely age, whether the enrollee resided in a county designated as a DHPSA[5], and year. Results can be understood as the average change in the outcome attributed to the change in each additional preventive dental care visit for each person. We used SAS 9.2[96] for data management and Stata SE version 17[97] to for all analyses.

Several sensitivity analyses were conducted. First, we evaluated results among a more restrictive sample of adults who had no NPVs in the first six months of enrollment (Appendix B, Tables B1 & B2). This was done to account for the possibility that those who received dental services during this time were different than other enrollees, such as having more chronic or previously unmet dental needs. Finally, we analyzed cost outcomes using the modal value paid by Medicaid for each procedure, rather than the paid amount as it appeared in the claims (Appendix B, Tables B3 & B4). This was done to assess any effect related to Medicaid's benefit limits, for example denying

[5] A county is designated as a dental health professional shortage area if the area has a population to full-time equivalent dentist ratio of at least 5,000:1 (or 4,000:1 in unusually high need areas) or if dental professionals in contiguous counties are over-utilized, too far in distance or inaccessible to the county population under consideration.[94]

reimbursement for some services provided over those limits (e.g. a maximum of 4 minor restorative visits per enrollment year are covered).

Results

A total of 28,152 adults (constituting 108,349 observation-years) met the study inclusion criteria. Population characteristics are presented in Table 4. Approximately 59% of the population were female, 76% were non-Hispanic white, and 45% were never married. On average, included individuals were enrolled continuously for approximately 43 months. Overall, 36.0% had a dental visit, 27.8% had a preventive dental visit, and 22.1% had a non-preventive dental visit.

Table 5 presents summary statistics for enrollees' overall annual number of dental services and expenditures, and the number of dental services and expenditures by year of enrollment, conditional on any dental care use. For all types of dental care (any, preventive, and non-preventive), a decreasing trend can be observed in the annual number of visits and expenditures per enrollee after their first year of enrollment. On average, among adults who had dental care, enrollees had 2.35 dental visits (SD=1.42) per enrollment period. This included 0.28 (SD=0.56) preventive visits and 0.94 (SD=1.03) non-preventive visits. The average total cost for all dental visits in a twelve-month enrollment period among adults with any dental visit was $352.47 (SD=270.34) per enrollee, $48.87 (SD=43.75) for preventive visits, and $177.34 (SD=230.95) for non-preventive visits.

Results from fixed effects linear regression models predicting the total number of NPVs, total NPV expenditures, and total dental expenditures following PDVs in the prior year are shown in Table 6. Compared to having no PDVs in the prior year, having at least

one PDV was associated with fewer NPVs (β=-0.29; 95% CI -0.31, -0.27), lower NPV expenditures (β=-$75.53; 95% CI -79.98, -71.08), and lower total dental expenditures (-$109.57; 95% -115.53, -103.62). Each additional PDV in the prior year was associated with fewer NPVs, lower NPV expenditures, and lower total dental expenditures. Similarly, compared to having no PDVs in the prior two years (Table 7), having at least one PDV was associated with fewer NPVs (β=-0.45; 95% CI -0.48, -0.42), lower NPV expenditures (β=-$105.79; 95% CI -112.12, -99.46), and lower total dental expenditures (β=-$145.70; 95% -153.99, -137.41). Each additional PDV in the prior two years was associated with fewer NPVs, lower NPV expenditures, and lower total dental expenditures. Overall, having at least four preventive visits in the prior two years was associated with fewer NPVs (β=-1.30; 95% CI -1.46, -1.14), lower NPV expenditures (β=-$264.68, 95% CI -301.63, -227.73), and lower total dental expenditures (β=-$354.25, 95% CI -402.66, -305.83).

Results from our sensitivity analyzes can be found in Appendix B. Findings were consistent with our main regression analyses. Given the robustness of these results, we have opted to present the least restrictive model as our main analysis.

Table 4: Characteristics of study population[a]

Characteristic	N (%)
Sex	
Male	44,833 (41.4)
Female	63,516 (58.6)
Marital status	
Married	33,941 (31.3)
Single	48,747 (45.0)
Widowed/Unknown	6,327 (5.8)
Divorced	19,334 (17.9)
Mean age (SD)	45.1 (12.0)
Race/ethnicity	
non-Hispanic white	82,295 (75.9)
Black	10,790 (10.0)
Hispanic	5,670 (5.2)
Other	9,594 (8.9)
Year	
2015	21,532 (19.9)
2016	27,170 (25.1)
2017	28,152 (26.0)
2018	31,495 (29.0)
Dental Health Professional Shortage Area designation[b]	
Not shortage area	39,523 (36.2)
Full or partial shortage area	69,096 (63.8)
Months enrolled, mean (SD)	42.8 (4.08)
Family size	
1	51,844 (47.9)
2	24,762 (22.9)
3	12,479 (11.5)
4	9,124 (8.4)
5 or more	9,602 (8.9)
Unknown	538 (0.5)
Any dental visit	39,013 (36.0)
Any preventive dental visit	30,153 (27.8)
Any non-preventive dental visit	23,892 (22.1)

Note: SD refers to standard deviation

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018. (N=108,349 adult observation-years)

[b] – Dental health professional shortage area as defined within Area Health Resource File from the U.S. Health Resources and Services Administration

Table 5: Summary statistics of dental visits and expenditures by year of enrollment among Medicaid enrollees[a] with any dental care use

	Overall N=39,013	Year 1 (Enrolled 12 months) N=11,030	Year 2 (Enrolled 24 months) N=10,869	Year 3 (Enrolled 36 months) N=10,370	Year 4 (Enrolled 37-47 months) N=6,744
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Visits					
Average number of dental visits	2.35 (1.42)	2.49 (1.52)	2.44 (1.48)	2.34 (1.35)	1.95 (1.15)
Average number of preventive[c] dental visits	0.28 (0.56)	0.37 (0.64)	0.28 (0.56)	0.25 (0.52)	0.20 (0.45)
Average number of non-preventive[d] dental visits	0.94 (1.03)	1.13 (1.14)	0.98 (1.05)	0.85 (0.95)	0.69 (0.82)
Expenditures per enrollee					
Average preventive[b] dental expenditures	$48.87 (43.75)	$43.91 (43.43)	$47.30 (43.15)	$53.15 (45.44)	$52.94 (41.54)
Average non-preventive[c] dental expenditures	$177.34 (230.95)	$224.50 (254.78)	$174.14 (224.65)	$157.87 (223.41)	$135.25 (195.77)
Average restorative[d] dental expenditures	$103.33 (160.31)	$125.12 (176.20)	$101.91 (157.26)	$93.76 (152.62)	$84.69 (144.76)
Average periodontic[e] dental expenditures	$0.77 (11.24)	$1.31 (11.15)	$0.79 (8.65)	$0.60 (14.03)	$0.13 (10.18)
Average endodontic[f] dental expenditures	$0.55 (11.65)	$0.76 (8.12)	$0.71 (9.62)	$0.49 (17.52)	$0.09 (7.50)
Average prosthodontic[g] dental expenditures	$0.19 (10.67)	$0.14 (3.64)	$0.22 (8.08)	$0.35 (18.60)	$0 (0)
Average oral surgery[h] dental expenditures	$70.31 (176.94)	$93.26 (203.65)	$67.78 (172.39)	$61.57 (167.17)	$50.32 (145.01)
Average total dental expenditures	$352.47 (270.34)	$432.35 (301.64)	$352.10 (263.74)	$317.88 (251.42)	$275.59 (215.64)

Note: Diagnostic visits and expenditures are not included in his table.
[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018
[b] – Preventive dental care encompasses procedures with CDT codes D1000-D1999 (e.g. dental prophylaxis, fluoride treatments, and dental sealants)
[c] – Non-preventive dental care encompasses procedures with CDT codes D2000-D9999 and includes restorative, periodontic, endodontic, prosthodontic, and surgical care.
[d] – Restorative services encompasses CDT codes D2000-D2999 (e.g. amalgam and composite fillings)
[e] – Periodontic services encompasses CDT codes D4000-D999 (e.g. scaling and root planning and periodontal maintenance)
[f] – Endodontic services encompasses CDT codes D3000-D3999 (e.g. root canal)
[g] – Prosthodontic services encompasses CDT codes D5000-D5999, D6200-D6999 (e.g. crowns)
[h] – Oral surgery services encompasses CDT codes (e.g. extractions)

Table 6: Fixed effects ordinary least squares regression models predicting the total number of non-preventive visits (NPVs), NPV expenditures, and total dental expenditures among Indiana Medicaid-enrolled adults[a] following preventive dental visits (PDVs) in the prior year

	Total number of NPVs	Total NPV expenditures	Total dental expenditures
	Coeff. (95% CI)	Coeff. (95% CI)	Coeff. (95% CI)
No prior PDV	ref	ref	ref
1 prior PDV	-0.29*** (-0.31, -0.27)	-75.53*** (-79.98, -71.08)	-109.57*** (-115.53, -103.62)
2 prior PDVs	-0.45*** (-0.50, -0.40)	-95.97*** (-106.60, -85.35)	-139.06*** (-153.28, -124.83)
3+ prior PDVs	-0.75*** (-0.86, -0.65)	-111.22*** (-134.96,-87.47)	-170.31*** (-202.08, -138.54)
Constant	10.42*** (9.42, 11.42)	1970.45*** (1748.90, 2192.00)	3678.63*** (3382.21, 3975.06)

Note: All models are adjusted for observed time-varying characteristics, namely age, dental health professional shortage area designation, and year.
ref = Reference category, omitted from model
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018. (N=28,152)

Table 7: Fixed effects ordinary least squares regression models predicting the total number of non-preventive visits (NPVs), NPV expenditures, and total dental expenditures among Indiana Medicaid-enrolled adults[a] following preventive dental visits (PDVs) in the prior two years

	Total number of NPVs	Total NPV expenditures	Total dental expenditures
	Coeff. (95% CI)	Coeff. (95% CI)	Coeff. (95% CI)
No prior PDV	ref	ref	ref
1 prior PDV	-0.45*** (-0.48, -0.42)	-105.79*** (-112.12, -99.46)	-145.70*** (-153.99, -137.41)
2 prior PDVs	-0.77*** (-0.82, -0.72)	-173.81*** (-185.58, -162.05)	-240.60*** (-256.02, -225.18)
3 prior PDVs	-1.00*** (-1.10, -0.91)	-221.82*** (-244.46, -199.17)	-293.26*** (-322.93, -263.59)
4+ prior PDVs	-1.30*** (-1.46, -1.14)	-264.68*** (-301.63, -227.73)	-354.25*** (-402.66, -305.83)
Constant	13.00*** (11.94, 14.06)	2600.98*** (2355.58, 2846.39)	4668.07*** (4346.53, 4989.62)

Note: All models are adjusted for observed time-varying characteristics, namely age, dental health professional shortage area designation, and year.
ref = Reference category, omitted from model
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018 (N=28,152).

Discussion

We examined the relationship between PDVs and NPVs and dental expenditures among Medicaid-enrolled adults with dental coverage. When accounting for within-person characteristics, we found having one or more PDVs in the previous year (or in the previous two years) was associated with fewer NPVs, lower non-preventive dental care expenditures, and lower overall dental expenditures. Further, as the number of PDVs increased in the previous year(s), the greater the decrease in subsequent NPVs, NPVs expenditures, and total dental expenditures. Therefore, overall our findings suggest preventive dental care is associated with improvement in oral health outcomes.

Moreover, the dose-response nature of the association also suggests that repetitive preventive dental care may have beneficial effects. However, since our panel of data was relatively short, we are unable to fully test this conjecture. We recommend additional research to determine the cumulative effects of repetitive PDVs in adults over a longer study period. Furthermore, given that we examined the first four years of HIP Plus program implementation, and thus a previously uninsured population, our results may be biased since enrollees may be addressing pent-up demand for non-preventive dental care in their first year of dental care use. Future research should examine potential adverse selection related to Medicaid dental care and how dental care use changes over time among Medicaid-enrollees.

In general, our findings are similar to Pourat et al. (2018)[57] who found preventive dental care was associated with lower overall dental expenditures among a sample of Medicaid-enrolled adults. While Pourat et al. (2018)[57] did not find preventive dental care was associated with fewer non-preventive dental care services, their findings did support

the notion that more frequent preventive services can help reduce or avoid extensive, and costly, non-preventive care. This current study, which accounted for individual characteristics that confound the relationship between preventive dental care and adverse oral health outcomes found evidence to suggest that preventive dental care is effective at reducing both non-preventive dental care use and associated expenditures. Optimal management of oral health relies on the early treatment of minor problems to prevent more invasive and more costly non-preventive treatments.[128] Thus, from an insurance program standpoint, encouraging the use of preventive dental care could lead to improved population oral health outcomes. This is a particularly salient point for states with adult Medicaid dental coverage, as these benefits are optional and often reduced or eliminated with state budgets are constrained.

Importantly, Pourat et al. (2018)[57] examined a sample of Medicaid-enrolled adults in California, a state with comprehensive or "extensive" dental benefits for its enrollees, whereas this current study examined a state which offers "limited" dental benefits for adults enrolled in the HIP Plus program. Similar to 15 other states, this level of generosity in dental benefits covers fewer than 100 of 600 dental procedures and generally focuses on prevention or emergency care, but limits the options for restorative care (i.e. root canals are not covered).[21] When we evaluated which specific non-preventive expenditures decreased the most in the year following at least one PDV, we found lower expenditures were primarily driven by fewer extraction services being performed (results available upon request). Previous work has shown that states' Medicaid expansion of adult dental coverage is associated with an increased likelihood of complete tooth loss among low-income adults.[131] Our evidence of reduced NPVs and

lower subsequent expenditures may indicate that covering limited dental services results in fewer non-preventive visits and lower costs, but may not preserve teeth. For some, years of neglected oral health may have resulted in irreparable damage to teeth, leaving extraction as the only option. Alternatively, even if other treatment options exist for restoring a tooth, a state's Medicaid dental coverage benefits may be limited such that the only affordable option is extraction. Thus, a better understanding of how quality of life is affected by the design of a state's dental insurance program is important to consider. Certain Medicaid dental coverage plans for low-income adults may not be structured to incentivize optimal oral health across one's lifespan.[116] Therefore, there is a need for additional research to determine the effects of program design (comprehensive vs. limited vs. emergency-only vs. no coverage) among dental benefits for Medicaid adults.

Although we lack information on enrollees' dental care utilization prior to program enrollment, we observed a pattern of decreased utilization of all types of dental care on average, over time. We found that despite common recommendations for adults to have regular dental care, the number of enrollees in our cohort having at least one yearly dental visit was inconsistent over time. More specifically, preventive dental care utilization decreased with each year of enrollment. Upon further investigation into our data, we also found that only 3% of Medicaid-enrolled adults (data not shown) followed commonly recommended preventive dental care schedules (at least two visits a year). These findings suggest other barriers to regular care beyond coverage may hinder repetitive and consistent utilization of preventive dental care. For example, lack of time to visit the dentist and inability to easily travel to see a dentist are consistent reasons reported by Medicaid-enrolled adults as to why they forgo visiting a dentist

annually.[133,134] Regardless, the irregular use of dental care among this population raises concerns about how dental care is delivered to and utilized by low-income adults. Additional research using robust mixed methods approaches is needed in order to determine the specific reasons why there is irregular use and the long-term consequences of such inconsistent care.

As a strength, this study employed an individual fixed effects study design which allowed us to reduce bias from unobserved time-invariant confounders. Furthermore, we provided insights into the dental services covered in a state Medicaid program that provides "limited" dental benefits, which has not been explored. Still, we have limitations worth noting. First, our study design does not allow us to control for unobserved time-varying factors that may confound the relationship between preventive dental visits and non-preventive dental visits and expenditures, such as health literacy campaigns, public service announcements beyond the Medicaid enrollment phase, or consumer incentives from managed care organizations. Further, we also lack relevant oral health diagnoses which likely motivate individuals' care-seeking behaviors and selection of treatment options. Given the short study time period, we are unable to rigorously analyze cumulative, repetitive preventive dental care. Finally, our findings may not generalize to adults who disenroll prior to 36 months of coverage or to low-income adults who have coverage in a state Medicaid program with a different level of generosity in dental benefits.

Conclusion

Our findings suggest that prior year PDVs are associated with fewer subsequent NPVs and lower dental expenditures among Medicaid-enrolled adults. Thus, from an

insurance program standpoint, supporting preventive dental care use may improve population oral health outcomes and lead to cost savings. Future research should explore these relationships over longer study time periods and across states with varying generosity plans for adult Medicaid dental benefits.

CHAPTER FOUR

THE RELATIONSHIP BETWEEN PREVENTIVE DENTAL CARE AND OVERALL MEDICAL EXPENDITURES AMONG MEDICAID-ENROLLED ADULTS – AN INSTRUMENTAL VARIABLE APPROACH

Introduction

Poor oral health is associated with pain,[7,8] decreased chewing function,[9] negative social perceptions,[13] and reduced quality of life.[14–17] Although the full causal pathways remain elusive, some evidence suggests an association of poor oral health and chronic diseases.[59–62,64–66] Regardless, preventing or reversing poor oral health may positively impact overall health by improving physical, psychological and social well-being.[68,69] For instance, some studies suggest having a dental prophylaxis (commonly referred to as a "dental cleaning") or a dental scaling reduces the risk of ischemic stroke,[140] esophageal cancer,[19] infective endocarditis,[20] Parkinson's disease,[21] and myocardial infarction.[22]

A hypothesized systemic-oral health link has led to investigations into whether provision of timely dental services can lead to improved health and reduced medical expenditures.[21,54,70,73,74,131] Private insurers have reported fewer hospital admissions (39% less) and fewer emergency room visits (36% less) among enrollees who receive preventive dental care at least once a year.[55] Among adults with gum disease, those who receive annual dental care have lower overall medical expenditures, fewer emergency room visits, and fewer annual in-patient admissions, compared to adults without annual dental care.[55,58,72] Additionally, several studies have reported significant lower medical expenditures among adults with periodontal disease who receive appropriate dental care treatments.[70–74,132] However, all of these studies are weak in internal validity and subject

to omitted variable bias. The effect of preventive interventions on health outcomes is often overestimated because, in general, individuals who seek preventive care are otherwise healthier than their counterparts.[133] In addition, current evidence on whether dental care impacts medical care expenditures is subject to bias from relevant unobserved factors (such as an individual's health literacy, hygiene habits, and level of health consciousness) which confound the relationship between dental care and medical outcomes.

This study will mitigate bias from key unobserved confounding factors by using an instrumental variable (IV) estimation method to determine the extent to which preventive dental care may be causally associated with overall medical expenditures. This will be accomplished using an appropriate IV, which is not associated with the outcome except through its effect on the predictor, and therefore should be unrelated to unobserved characteristics that influence the outcome. If the IV is valid, estimation methods can control for common forms of bias in observational studies such as measurement error, simultaneity, and omitted variables, all which prevent causal interpretations of relationships. In particular, we examine how preventive dental care is related to medical and pharmacy expenditures in a population of low-income Medicaid-enrolled adults using a measure of dental care access as the instrument. Our findings have implications for overall state public insurance policy, as adult Medicaid dental benefits vary greatly across states and may be targeted for reductions when state budgets are constrained.[21,116,134] Further, our IV may be of interest to other researchers who examine the relationship between dental care and medical outcomes.

Methods

Data & Study Population

We used administrative claims and enrollment data from the Indiana Family and Social Services Administration Office of Medicaid Policy and Planning. Additional economic and county-level population data was derived from the Health Resources and Service Administration's Area Health Resources File (AHRF).[90]

Using a Section 1115 waiver, Indiana expanded Medicaid eligibility in 2015 to non-disabled adults (ages 19 to 64) with incomes up to 138% of the Federal Poverty Level (FPL).[86,87] Under the Healthy Indiana Program (HIP) Plus program, enrollees are provided comprehensive health benefits that include coverage for dental services.[87] We constructed a study population with stable Medicaid coverage, because churn or other coverage disruptions are associated with delayed care, less preventive care, and more emergency department visits among Medicaid adults.[139] Therefore, to be included in the study, we used data from adults who were continuously enrolled in the HIP Plus program for at least 36 months between February 1, 2015 and December 31, 2018. We used the first year of enrollment as a baseline year to define our independent variable and the second continuously enrolled year as the measurement year to calculate our dependent variables. We excluded enrollees whose medical expenditures were above the top 5% of total annual medical expenditures (greater than $16,251) since these individuals likely have profound health conditions beyond the average adult enrollee.

Dependent variable

For each twelve month period of enrollment, we summed annual expenditures from enrollees' medical and pharmacy claims. Given the nontrivial number of enrollees

(n=3,053; 12.5%) who had no medical expenditures ($0) and the positively skewed distribution of health expenditure data, we separately examined the probability of the individual having any expenditures, and examined total expenditures (log-transformed) conditional on having any positive expenditure. For medical expenditures, we excluded all expenditures from claims with International Classification of Diseases (ICD) 9-CM/10-CM diagnoses codes related to oral conditions and diseases,[139] since these expenditures are directly associated with receipt of dental care (e.g. emergency department visits for non-traumatic dental care). See Appendix C, Tables C1 & C2 for the full list of ICD 9-CM/10-CM dental diagnosis codes. In a similar two-part fashion, we analyzed all annual pharmacy expenditures. Expenditures were adjusted for inflation using the 2019 Consumer Price Index.[121]

Endogenous main explanatory variable

The main explanatory variable of interest was a one-year lagged binary variable indicating whether the adult had any preventive dental visit (PDV) within a twelve-month enrollment period. Using the Healthcare Effectiveness Data and Information Set Definition (HEDIS),[122] PDVs were identified by dental claims which included Common Dental Procedure (CDT) codes D0120, D0150, and D1000-D1999, but were absent of CDT codes D2000-D9999 (non-preventive dental procedures).[122] Thus our explanatory variable identified preventive-only dental visits. As a secondary variable of interest we did not lag the binary indicator of whether the adult had a PDV within the last twelve months.

Independent variables

Individual-level characteristics included in our analyses were: sex (male, female), race (White, Black, Hispanic, and other), age, marital status (married, never married, divorced, widowed/unknown), living arrangement (lives in a home, homeless, communal living facility, unknown), family size (1, 2, 3, 4, 5 or more, unknown), and the total number of months continuously enrolled in Medicaid. Additionally, we included whether a medical annual well visit had occurred, defined as the presence of a medical claim with Current Procedural Terminology Codes 99385, 99386, 99387, 99395, 99396, or 99397.[74] We also controlled for the total number of annual chronic disease encounters, defined by the Healthcare Cost and Utilization Chronic Condition indicator tool for ICD-9-CM[45] and ICD-10-CM[46] which flagged claim diagnoses as related to chronic conditions. Any medical claim flagged as having a chronic disease diagnosis was counted as a chronic disease encounter.

We used the enrollee's geocoded primary home address[6] to obtain the county and census block where the enrollee resided in order to link county-level factors from AHRF. Specifically, we included whether the county was designated as a full or partial primary care health professional shortage area (HPSA)[7] (yes, no), and the number of persons unemployed within the county. We also characterized the rurality of each county using Rural-Urban Commuting Area codes (RUCA [urban, large rural, small rural, isolated]).[91]

[6] We designated the modal address as the primary for enrollment periods where the enrollee had multiple addresses.

[7] A county is designated as a HPSA if the area has a population to full-time equivalent primary care doctor ratio of at least 3,500:1 (or 3,000:1 in unusually high need areas) or if primary care professionals in contiguous counties are over-utilized, too far in distance or inaccessible to the county population under consideration.[94]

Instrumental Variable

Since individuals who seek preventive dental care may also seek preventive medical care more often than other adults, our naïve model specification is subject to omitted variable bias. Unobserved individual characteristics, such as oral hygiene behaviors and health consciousness, motivate adults to self-select dental care services, and can influence attitudes and behavior towards medical care. To address this bias, we computed an IV that represents a measure of dental care access. Specifically, we defined our IV as the number of adult enrollees with at least one non-preventive dental claim[8] per total enrollees within a census tract per year.

Certain assumptions must hold for an IV to produce valid causal estimates. The instrument must strongly predict the endogenous explanatory variable, but cannot be directly related to the outcome of interest and unobserved confounding factors.[34] We assumed our instrument would strongly predict whether a Medicaid-enrolled adult had a preventive dental visit within a twelve-month period but would not be directly related to medical expenditures or to unobserved confounders that affect enrollee's medical expenditures. Whether or not the IV strongly predicts the endogenous explanatory variable (i.e. the relevance assumption) is testable by regressing the endogenous predictor variable on the IV and covariates. An F statistic greater than 10 to considered a strong IV.[49] F-statistics from all first stage regressions of the IV estimation models in this study ranged from 153.1 to 290.6 and indicated we identified a sufficiently powerful instrument. Whether or not the IV is correlated with the error term is not directly testable

[8] Defined as the presence of a dental claim with CDT codes representing non-preventive procedures (D2000-D9999) and the absence of CDT codes representing preventive dental care (D1000-D1999) on the same claim.

(i.e. the exclusion restriction), but certain falsification tests can be conducted to judge the quality of the IV, such as balance testing of observed covariates or overidentification tests with additional instruments.[50,51]

Analysis

Descriptive characteristics of the population are presented as frequencies and means. We investigated the validity of our instrument by calculating the standardized mean difference in covariates above and below the median value of the IV. Standardized mean difference values between -0.1 and 0.1 indicate balance in observable covariates across groups.[51] After estimating "naïve" regression results where PDV status is treated as exogenous, we estimated all outcomes using two-stage least squares regressions. First-stage fitted values from the regressions of PDVs on our IV replaced the endogenous measure of PDVs in the second stage of the regressions. We estimated separate models for lagged effects (PDVs lagged from the baseline year) and for concurrent effects (PDVs in the same measurement year). All models were adjusted for sex, race/ethnicity, marital status, living arrangement, family size, year, total number of chronic encounters, total months enrolled, annual well visit, prior year expenditures, RUCA designation, number of persons unemployed, and HPSA designation.

We present estimates from our models as percentage point differences in the likelihood of having any expenditures greater than $0. From the conditional models with log-transformed expenditures, we present elasticities ($\boldsymbol{e^{\beta} - 1}$) as the percentage change of total expenditures associated with PDV. We conducted sensitivity analyses by examining all outcomes in enrollees' third and fourth enrollment years. Through falsification tests, we evaluated higher orders of the IV. All p-values on overidentification

tests were statistically insignificant at an $\alpha = 0.05$ and thus we failed to reject the null hypothesis that the instruments were uncorrelated with the residual error term. Since all models with higher order instruments lowered first-stage F-statistics, we present all models as just-identified with the instrument set at level value. All estimates were reported at 95% confidence intervals. Data were managed with SAS 9.2[96] and analyzed with Stata SE version 17[53].

Results

The study population consisted of 24,424 enrollees, of whom the majority were female (57.8%), white (75.2%), and lived in urban counties (72.9%) (see Table 8). On average, an enrollee was 44 years old and had 2.4 chronic medical encounters in a year. Individuals who had a PDV within a twelve-month enrollment period were more likely to be female (66.3% vs. 54.4%), married (32.6% vs. 30.8%), and had an annual well visit (37.4% vs. 22.8%) (all p-values <0.001). Among those with any medical expenditures (87.5%), enrollees had on average $2,733 (SD=$3,101) in annual medical expenditures. Among those with any pharmacy expenditures (78.1%), individuals had on average $850 (SD=$1,535) in yearly pharmacy expenditures.

Table 9 presents observed covariates by IV status (i.e. above and below the median IV value). Since all standardized mean differences between group covariates are between -0.1 and 0.1, any differences between the two groups are not considered meaningful. Thus, our IV simulates a random "flip of a coin" in how it balances observable baseline covariates across groups. While this falsification test does not definitively prove the exclusion restriction assumption, the balance of observable factors

by IV status provides some validation that the IV would plausibly balance the distribution of unobservable factors between the two groups.

Naïve and IV estimates of the effect of a PDV on medical and pharmacy cost outcomes following enrollees' second twelve-month period of enrollment are presented in Tables 10 and 11. In naïve analyses, compared to enrollees without a PDV, those enrollees with a prior year PDV had a 2.4 percentage point (95% CI 1.7, 3.1) greater likelihood of having any medical expenditures and had 3.6 percent greater medical expenditures (95% CI 0.3, 7.1). Similarly, enrollees who had a prior year PDV were 5.2 percentage points more likely to have any medical expenditures (95% CI 4.5, 5.8) and had 4.4 percent greater total medical expenditures within the same year (95% CI 1.0, 7.9). Naïve estimates suggest a greater likelihood of an adult having any pharmacy expenditures regardless of whether the PDV happened in the year prior (1.3; 95% CI 0.3, 2.2) or the same year (5.6; 95% 4.7, 6.5), but suggest no effect on (logged) pharmacy expenditures.

Analyses from IV estimation methods indicate that having a PDV in the prior or same year was not statistically significantly related to the likelihood of having any medical expenditures, or (logged) medical expenditures among those who received any medical care. Similarly, having a PDV in the prior or same year had no statistically significant effect on the likelihood of having any pharmacy expenditures, or (logged) pharmacy expenditures among those who received any pharmacy care.

Estimates from sensitivity analyses when using third and fourth period of enrollments were consistent with our main results (see Appendix C, Tables C3, C4, C5, & C6). However, one notable exception was enrollees in their third period of enrollment

(Appendix C, Table C3). In this cross-sectional IV analysis, we observed that having a PDV resulted in a greater likelihood of having any medical expenditures (12.2 pps; 95% CI 2.6, 21.4) and any pharmacy expenditures (14.4 pps; 95% CI 3.1, 25.7) in the same year.

Table 8: Characteristics and cost outcomes among Indiana Medicaid-enrolled adults[a], total and by preventive dental visit (PDV) status

Characteristic	Total	No PDV within 12 months	PDV within 12 months
Total enrollees (percent of total)	24,424 (100)	17,325 (70.9)	7,099 (29.1)
Demographic characteristics			
Sex			
Female	14,126 (57.8)	9,422 (54.4)	4,704 (66.3)
Male	10,298 (42.2)	7,903 (45.6)	2,395 (33.7)
Race/Ethnicity			
White	18,377 (75.2)	13,121 (75.7)	5,256 (74.0)
Black	2,529 (10.4)	1,793 (10.4)	736 (10.4)
Hispanic	1,345 (5.5)	883 (5.1)	462 (6.5)
Other	2,173 (8.9)	1,528 (8.8)	645 (9.1)
Marital Status			
Married	7,646 (31.3)	5,329 (30.8)	2,317 (32.6)
Never married	11,233 (46.0)	8,025 (46.3)	3,208 (45.2)
Divorced	4,111 (16.8)	2,898 (16.7)	1,213 (17.1)
Widowed/Unknown	1,434 (5.9)	1,073 (6.2)	361 (5.1)
Living arrangement			
Lives in a home	23,120 (94.7)	16,343 (94.3)	6,777 (95.4)
Homeless	967 (4.0)	728 (4.2)	239 (3.4)
Communal living facility	76 (0.3)	63 (0.4)	13 (0.2)
Unknown	261 (1.0)	191 (1.1)	70 (1.0)
Family size			
1	11,443 (46.8)	8,381 (48.4)	3,062 (43.1)
2	5,513 (22.6)	3,930 (22.7)	1,583 (22.3)
3	2,892 (11.8)	1,952 (11.3)	940 (13.2)
4	2,145 (8.8)	1,430 (8.2)	715 (10.1)
5 or greater	2,262 (9.3)	1,507 (8.7)	755 (10.7)
Unknown	169 (0.7)	125 (0.7)	44 (0.6)
Age, mean (SD)	44.0 (12.1)	45.5 (12.0)	42.9 (12.3)
Annual well visit			
Yes	6,608 (27.1)	3,950 (22.8)	2,658 (37.4)
No	17,816 (72.9)	13,375 (77.2)	4,441 (62.6)
Total months enrolled (SD)	42.4 (4.2)	42.4 (4.2)	42.6 (4.2)
Total number of chronic encounters (SD)	2.4 (4.3)	2.2 (4.1)	2.8 (4.8)
County-level characteristics			
RUCA[b] designation			
Urban	19,018 (77.9)	13,437 (77.6)	5,581 (78.6)
Large rural	3,332 (13.6)	2,416 (13.9)	916 (12.9)
Short rural	1,292 (5.3)	906 (5.2)	386 (5.4)
Isolated	782 (3.2)	566 (3.3)	216 (3.1)

HPSA[c] designation			
No shortage area	3,898 (16.0)	2,676 (15.5)	1,222 (17.2)
Full or partial shortage area	20,526 (84.0)	14,649 (84.5)	5,877 (82.8)
Number unemployed, mean (SD)	5,998.6 (6812.5)	5,964.4 (6827.3)	6,086 (6772.8)
Cost outcomes[d]			
Enrollees with any medical[e] expenditures	21,371 (87.5)	14,602 (84.3)	6,769 (95.4)
Enrollees with any pharmacy expenditures	19,073 (78.1)	12,922 (74.6)	6,151 (86.7)
Average medical[e] expenditures among those with positive expenditures (SD)	$2733 (3101)	$2661 (3095)	$2887 (3108)
Average pharmacy expenditures among those with positive expenditures (SD)	$850 (1535)	$872 (1575)	$805 (1446)
Annual medical[e] expenditures (SD)	$2391 (3038)	$2243 (3002)	$2753 (3095)
Annual pharmacy expenditures (SD)	$66 (1401)	$650 (1412)	$698 (1373)

Note: SD indicates standard deviation

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Rural-Urban Commuting Areas as defined by the US Department of Agriculture

[c] – Primary care health professional shortage area as defined within Area Health Resource File from the US Health Resources and Services Administration

[d] – All costs rounded to nearest U.S. dollar amount and adjusted for inflation using the 2019 Consumer Price Index

[e] – Includes pharmacy expenditures

Table 9: Characteristics of Indiana Medicaid-enrolled adults[a] by instrumental variable (IV) status[b]

Characteristic	IV Status		Standardized Difference
	Below Median (n=12,519)	Above Median (n=11,905)	
Sex			<0.01
Female	7,211 (57.6)	6,915 (57.8)	
Male	5,308 (42.4)	4,990 (42.2)	
Race			0.05
Non-Hispanic white	9,305 (75.3)	9,072 (76.2)	
Black	2,336 (10.7)	1,193 (10.0)	
Hispanic	703 (5.6)	642 (5.4)	
Other	1,175 (9.4)	988 (8.4)	
Marital Status			0.04
Married	3,850 (30.8)	3,796 (31.9)	
Single	5,840 (46.6)	5,393 (45.3)	
Divorced	2,070 (16.5)	2,041 (17.1)	
Widowed/unknown	759 (6.1)	675 (5.7)	
Living Arrangement			0.02
Lives in home	11,828 (94.5)	11,292 (94.9)	
Communal living facility	42 (0.3)	34 (0.3)	
Homeless	520 (4.2)	447 (3.8)	
Unknown	219 (1.0)	123 (1.0)	
Family size			0.04
1	5,986 (47.8)	5,457 (45.8)	
2	2,758 (22.0)	2,755 (23.1)	
3	1,463 (11.7)	1,429 (12.0)	
4	1,078 (8.6)	1,067 (9.0)	
5 or more	1,153 (9.2)	1,109 (9.3)	
Unknown	81 (0.6)	88 (0.7)	
Age, mean	44.1 (12.2)	44.0 (12.0)	<0.01
Annual well visit	3,382 (27.0)	3,226 (27.1)	<0.01
Total months enrolled (SD)	42.5 (4.0)	42.9 (4.1)	-0.09
Total number of chronic encounters (SD)	2.6 (4.5)	2.2 (4.0)	0.10
RUCA[b] designation			0.03
Urban	9,822 (78.5)	9,196 (77.2)	
Large rural	1,668 (13.3)	1,664 (14.0)	
Short rural	647 (5.2)	645 (5.4)	
Isolated	382 (3.1)	400 (3.4)	
Full/Partial HPSA[c] designation	10,554 (84.3)	9,973 (83.8)	0.01
Number unemployed, mean (SD)	6,514 (7215.1)	6050 (6799.4)	0.06

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Instrumental variable: the number of adult enrollees with any non-preventive dental claims per total enrollees within a census tract per year

[c] – Rural-Urban Commuting Areas as defined by the US Department of Agriculture

[d] – Primary care health professional shortage area as defined within Area Health Resource File from the US Health Resources and Services Administration

Table 10: Results of ordinary least squares (OLS) and instrumental variable (IV) regression models estimating the effect of a prior or same year preventive dental visit (PDV) on the likelihood of any medical and pharmacy expenditures among Indiana Medicaid-enrolled adults[a] in their second twelve-month period of enrollment

	Percentage change in the likelihood of having any medical expenditures[b] N=(24,424) Coeff. (95% CI)	Percentage change in the likelihood of having any pharmacy expenditures (N-24,424) Coeff (95% CI)
PDV in prior year		
OLS Model	2.4 (1.7, 3.1)***	1.3 (0.3, 2.2)**
IV Model	2.8 (-10.2, 4.7)	-8.5 (-17.6, 5.0)
PDV in same year		
OLS Model	5.2 (4.5, 5.8)***	5.6 (4.7, 6.5)***
IV Model	9.4 (-0.3, 19.0)	1.7 (-9.9, 13.3)

Note: All estimates are adjusted for gender, race/ethnicity, marital status, living arrangement, family size, year, total number of chronic encounters, total months enrolled, annual well visit, year prior expenditures, RUCA designation, number unemployed, & HPSA designation. Robust standard errors were clustered at the individual level.

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Including pharmacy expenditures

*p<0.05, **p<0.01***p<0.001

Table 11: Results of ordinary least squares (OLS) and instrumental variable (IV) regression models estimating the effect of a prior or same year preventive dental visit (PDV) on (logged) medical and pharmacy expenditures among Indiana Medicaid-enrolled adults[a] in their second twelve-month period of enrollment

	Total medical expenditures (logged)[b,c] (N=20,019) Coeff. (95% CI)	Total pharmacy expenditures (logged)[c] (N=16,827) Coeff (95% CI)
PDV in prior year		
OLS Model	3.7 (0.3, 7.1)*	-1.9 (-5.9, 1.9)
IV Model	-0.4 (-32.0, 33.2)	-13.7 (-56.5, 21.0)
PDV in same year		
OLS Model	4.4 (1.0, 7.9)*	-0.1 (-4.0, 3.9)
IV Model	9.2 (-58.9, 33.1)	-13.2 (-71.8, 34.0)

Note: All estimates are adjusted for gender, race/ethnicity, marital status, living arrangement, family size, year, total number of chronic encounters, total months enrolled, annual well visit, year prior expenditures, RUCA designation, number unemployed, & HPSA designation. Robust standard errors were clustered at the individual level.

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018
[b] – Including pharmacy expenditures
[c] – Conditional on positive expenditures
*p<0.05, **p<0.01***p<0.001

Discussion

This is the first study to present estimates with causal inference from a quasi-experimental study of the effect of PDVs on medical health, as measured by medical and pharmacy expenditures. We examined the effect of PDV on overall medical and pharmacy expenditures using a strong econometric technique to mitigate bias from unobserved confounding factors. Specifically, we used an IV regression approach, which has not previously been used within the context of PDV and medical expenditures. Our IV appears plausibly valid and may be a useful approach for future studies that evaluate the effect of adult preventive care on medical outcomes of interest. Randomized control trials are considered the gold-standard for generating causal findings, but such designs face considerable ethical, cost, and timing challenges, especially when resources are limited. In contrast, the IV used in this study may feasibly generate valid findings using existing administrative claims data from other states, insurance programs, and populations.

Our naive regression results showed a positive relationhip between PDV and medical expenditures, which is in contrast to other previous studies.[55,58] These unexpected findings may be related to differencces in our study population (low-income adults) compared to previously studied populations (privately insured adults). Our naive results may also be affected by the timing of our study which occured during the first four years of HIP Plus program implementation following Medicaid expansion in Indiana. Given that many in our study population were previously uninsured, these adults may have had significant pent up demand for both medical and dental care, thus positively skewing our naive results.

Our IV regression results showed no statistically significant relationship between PDV and medical health, as measured by total medical and pharmacy expenditures. Differences in our findings compared to previous studies are likely due to four reasons. First, previous studies have had simple observational study designs which are not able to control for endogenous factors associated with PDVs and medical expenditures, including health behaviors, beliefs, and practices that influence how medical care is sought and engaged with by adults. We used a robust econometric approach to mitigate bias and present results with strong internal validity. Second, several previous studies have focused on a subset of the adult population with diagnosed periodontal disease, primarily because prevailing hypotheses claim treatment of periodontal disease leads to reduced overall medical expenditures, particularly among adults who have other chronic diseases.[70–73] Our study did not narrow inclusion to adults who had periodontal disease or chronic conditions with previously documented associations with poor oral health. Thus, we recommend caution in extrapolating our observed effect of PDV to periodontal treatments on medical expenditures. Third, our definition of preventive dental care varies from other studies. We evaluated the effect of preventive dental visits with preventive procedures only and included no treatment services whatsoever in our definition. In contrast, Lamster et al. (2021)[74] found preventive dental care was associated with reductions in inpatient admission and emergency department costs among Medicaid-enrolled adults in New York. However, their definition of preventive dental care included non-preventive treatments for periodontal disease.[74] We recommend additional research, strong in internal validity, to evaluate the effect of certain dental treatments on overall and disease-specific expenditures, particularly in low-income populations who have

higher rates of periodontal disease than other adults.[6] Fourth, we examined the first four years of the HIP Plus program, and therefore a study population previously uninsured. Thus, among a population with potential for significant pent up demand, restoration of oral health may be needed before reductions in overall medical expenditures can occur through preventive care. A longer study period is needed to test these conjectures and to determine if long-term repetitive PDVs may have benefits not observed in our short study period.

While this is the first study to present causal estimates of the effect of PDVs on overall medical expenditures, our study is not without limitations. Our IV estimation method has strong internal validity but limited external validity. Our results derived from the IV estimation method may not generalize to adults outside this study population, such as those with different socioeconomic status, insurance coverage, and disease statuses. Further our findings may not generalize to Medicaid-enrolled adults who disenroll over time or who reside in other states. Use of our proposed instrument in those populations should be considered. In addition, not all of the assumptions associated with our IV estimation method are directly testable. However, as a strength, we conducted falsification tests by evaluating whether or not the instrument balanced observable covariates and by testing higher order IVs to examine the plausibility of the proposed instrument being valid. Notably, we excluded dental-related diagnoses from medical expenditures and thus cannot draw conclusions about any potential association with PDV in this way. For example, emergency-department (ED) visits for non-traumatic dental care (e.g. tooth pain) were excluded from our analysis and warrant further investigation with different methodologies. We did not track specific disease comorbidities but did

attempt to control for an individual's overall disease burden by adjusting for each enrollee's total number of chronic disease encounters and prior year medical expenditures. Finally, given our short study time period, we presented results from a limited longitudinal dataset. Future work should examine how the IV performs when predicting expenditures over time while accounting for different patterns of within-person PDV utilization.

Conclusion

This is the first study to present causal estimates of the effect of PDVs on overall medical expenditures. We found preventive dental visits did not have an effect on overall medical or pharmacy expenditures in the same or subsequent year. Additional research is needed to explore the effect of specific dental treatments on medical expenditures and whether preventive dental care has an impact on emergency department visits and expenditures.

CHAPTER FIVE

CONCLUSION

Given that low-income adults have disproportionally worse oral health and use dental services at lower rates compared to higher-income adults, the purpose of this dissertation was to examine factors and outcomes associated with dental care use among Medicaid-enrolled adults with dental benefits. More specifically, Chapter 2 described select correlates of dental care use among Medicaid-enrolled adults at the individual- and county- level. Chapter 3 examined the effect of preventive dental visits on non-preventive dental visits and dental expenditures among Medicaid-enrolled adults. Finally, Chapter 4 examined the relationship between preventive dental visits and overall medical expenditures among Medicaid-enrolled adults.

Cost is not the only barrier to dental care for low-income adults, and simply providing dental coverage may not practically expand access, increase use of dental care, or improve oral health. Thus, the aim of Chapter 2 was to determine whether other select individual- and county-level characteristics, beyond coverage, are associated with dental care use among low-income adults. We specifically analyzed data from the Healthy Indiana Plan Plus program and Indiana's State Plan Plus program. Using a pooled cross-sectional study design, we measured the associations of individual characteristics (such as annual well visits and distance to nearest dentist) and county-level factors (including supply of Medicaid-participating dentists and rurality) with dental care use among low-income adults to gain a better understanding of potential barriers and facilitators. Overall, we observed that less than half of enrollees received dental care during a yearly enrollment period and less than one-third had a preventive dental visit, despite having

preventive dental benefits. Among individual-level factors, the strongest predictor of an enrollee having any dental care use was having an annual well visit. Adults who intrinsically value health care may be more likely to seek care and/or adhere to recommended routine dental care schedules. Further, other factors, such as race, sex, and marital status, are important predictors of dental care use. We also found differences in the type of dental care received by race and ethnicity. Thus, more granular research into these racial/ethnic differences in dental care use is warranted to better understand these gradations in care. Further, we found that the county-level dentist-to-population ratio was not a statistically significant predictor after controlling for other factors, whereas the supply of Medicaid-participating dentists was associated with increased adult dental care use. Thus, simply measuring dentist-to-population ratio at the county- or state-level may be an imprecise measure of access for Medicaid-insured adults, and therefore policymakers and researchers evaluating Medicaid programs should be careful to consider detailed measures of supply relative to the population they are studying. In addition to provider supply measures, we found enrollees residing in counties designated as large rural areas were significantly less likely to have any dental visit and any preventive dental visit in a twelve-month enrollment period compared to enrollees residing in urban areas. Overall, these findings may inform oral health workforce recruitment efforts in geographic areas with low resources.

Given the high prevalence of poor oral health among low-income adults, determining whether preventive dental care is effective against adverse oral health outcomes is particularly important from a population health and public insurance program perspective. Therefore, the aim of Chapter 3 was to examine whether and to

what extent preventive dental visits are associated with non-preventive dental visits, non-preventive expenditures, and overall dental expenditures among a population of Medicaid-enrolled adults. Given that previous observational studies have failed to control for relevant individual-level confounding factors when studying the relationship between preventive dental care and oral health outcomes, we utilized an econometric technique that reduces bias from within-person unobserved time-invariant characteristics. Overall, we found that having one or more preventive dental visits in the previous year, or in the previous two years, was associated with fewer non-preventive visits, lower non-preventive dental care expenditures, and lower overall dental expenditures. Further, as the number of preventive dental visits increased in the previous year(s), the greater the decrease subsequent non-preventive dental visits, non-preventive visit expenditures, and total dental expenditures. Thus, from an insurance program standpoint, encouraging the use of preventive dental care could lead to cost savings and improved population oral health outcomes. We also observed that despite common recommendations for adults to have regular dental care, the number of Medicaid adult enrollees with at least one yearly dental visit was inconsistent over time, particularly when it comes to preventive dental care use. Therefore, our work underscores the need to further explore how dental care is delivered to, and utilized by low-income adults, so that program coverage policies and population oral health quality metrics are optimized.

Beyond determining whether preventive dental care affects oral health outcomes, we also explored whether preventive dental care can lead to improved overall health, as measured by medical expenditures. Previous studies exploring preventive dental care and medical expenditures are weak in internal validity and subject to omitted variable bias.

Therefore, the aim of Chapter 4 was to examine the relationship between preventive dental visits and overall medical expenditures using an instrumental variable estimation method. This method reduces bias from endogenous factors and provides consistent causal estimates, even in the presence of unobserved confounders. We found no statistically significant relationship between preventive dental visits and total medical or pharmacy expenditures. In addition, the instrument used in this study was a measure of dental care access and may feasibly be replicated in other studies which utilize administrative claims data from other states, insurance programs, and populations to generate additional robust findings. Overall, this study provided causal evidence on the relationship between preventive dental care and medical expenditures. There is still a need for additional research to explore the effect of specific dental treatments on medical expenditures and whether preventive dental care has an impact on emergency department visits and expenditures.

Collectively, these chapters contribute to a greater understanding of adult dental care use among Medicaid-enrolled adults, which has been previously understudied. This work identified additional correlates, beyond coverage, of dental care use that may require targeted interventions to adequately address and improve Medicaid-enrolled adults' oral health needs. Stakeholders can use findings from this dissertation to inform policy at the community and state level. Further, this dissertation helped to quantify the individual and economic value of dental care for adult Medicaid enrollees. We used robust methodological techniques to determine the effect of preventive dental care on oral health outcomes and overall dental expenditures. These findings have significant implications for clinical dental care, as well as the design and cost of adult Medicaid

dental insurance programs. Finally, this work presented causal evidence as to whether preventive dental care is related to medical expenditures, which has thus far been very limited and weak in internal validity. My findings challenge conventional wisdom and contribute to an overall understanding of the relationship of preventive dental care and medical outcomes among a population of adults. More nuanced relationships between preventive dental care and specific medical conditions are warranted, as this body of work suggests.

Overall this dissertation provides evidence that may inform Medicaid policy interventions focused on reducing oral health disparities and improving oral and overall health among vulnerable populations. In addition, this work has implications on overall program costs especially since public dental benefits are often at risk of being cut or eliminated when state budgets are constrained. Finally, this work could be used to inform state administrators and decision-makers who are trying to determine the optimal balance of covered services with public insurance policies among states with limited budgetary resources.

APPENDIX A

CHAPTER 2 SUPPLEMENTAL MATERIAL

Table A1: Sensitivity Analysis - Results (partial effects) of multi-level linear probability models of receipt of any dental visit (ADV), any preventive dental visit (PDV), and any non-preventive dental visit (NPV) among Indiana Medicaid-enrolled adults[a] who were enrolled for at least 11 months

	ADV	PDV	NPV
No annual well visit	0 (.)	0 (.)	0 (.)
Annual well visit	0.0821*** (0.000)	0.0890*** (0.000)	0.0476*** (0.000)
Male	0 (.)	0 (.)	0 (.)
Female	0.0573*** (0.000)	0.0524*** (0.000)	0.0320*** (0.000)
White	0 (.)	0 (.)	0 (.)
Black	0.0282*** (0.000)	0.0160*** (0.000)	-0.0000229 (0.990)
Hispanic	0.0168*** (0.000)	0.0297*** (0.000)	-0.0126*** (0.000)
Other race	-0.00365 (0.163)	-0.000528 (0.825)	-0.0123*** (0.000)
Marital Status (Married)	0 (.)	0 (.)	0 (.)
Marital Status (Never married)	-0.0112*** (0.000)	-0.0112*** (0.000)	-0.00456** (0.004)
Marital Status (Widowed/Unknown)	-0.0380*** (0.000)	-0.0300*** (0.000)	-0.0210*** (0.000)
Marital Status (Divorced)	0.0160*** (0.000)	-0.00290 (0.136)	0.0212*** (0.000)
Living arrangement (Lives in a home)	0 (.)	0 (.)	0 (.)

Living arrangement (Communal living facility)	-0.0138*	-0.0343***	0.000226
	(0.047)	(0.000)	(0.970)
Living arrangement (Homeless)	-0.00627	-0.0156***	-0.00593
	(0.101)	(0.000)	(0.067)
Living arrangement (Unknown)	-0.0137***	-0.00396	-0.0123***
	(0.000)	(0.204)	(0.000)
Family size (1)	0	0	0
	(.)	(.)	(.)
Family size (2)	0.00611***	0.00695***	0.00305
	(0.001)	(0.000)	(0.051)
Family size (3)	0.00662**	0.00920***	0.00383*
	(0.002)	(0.000)	(0.031)
Family size (4)	0.00574*	0.0104***	0.000808
	(0.018)	(0.000)	(0.695)
Family size (5 or more)	0.00100	0.00705**	-0.00604**
	(0.702)	(0.003)	(0.006)
Family size (unknown)	-0.00490	-0.00303	-0.00633
	(0.564)	(0.701)	(0.416)
Ages 19-24	0	0	0
	(.)	(.)	(.)
Ages 25-34	-0.00335	-0.0288***	0.0246***
	(0.125)	(0.000)	(0.000)
Ages 35-44	-0.0201***	-0.0367***	0.0122***
	(0.000)	(0.000)	(0.000)
Ages 45-54	-0.0465***	-0.0545***	-0.00737***
	(0.000)	(0.000)	(0.000)
Ages 55-64	-0.0797***	-0.0657***	-0.0353***
	(0.000)	(0.000)	(0.000)
Months enrolled (12-19 months)	0	0	0
	(.)	(.)	(.)
Months enrolled (20-28 months)	0.0249***	0.0267***	0.0186***
	(0.000)	(0.000)	(0.000)
Months enrolled (29-40 months)	0.0468***	0.0496***	0.0326***
	(0.000)	(0.000)	(0.000)
Months enrolled (41-47 months)	0.0646***	0.0735***	0.0383***

	(0.000)	(0.000)	(0.000)
Period of enrollment (1)	0	0	0
	(.)	(.)	(.)
Period of enrollment (2)	-0.0214***	-0.0247***	-0.0271***
	(0.000)	(0.000)	(0.000)
Period of enrollment (3)	-0.0184***	-0.0234***	-0.0342***
	(0.000)	(0.000)	(0.000)
Period of enrollment (4)	-0.0163***	-0.0226***	-0.0478***
	(0.000)	(0.000)	(0.000)
2015	0	0	0
	(.)	(.)	(.)
2016	0.00118	0.000225	-0.0000934
	(0.488)	(0.886)	(0.953)
2017	-0.0161***	-0.00920***	-0.0149***
	(0.000)	(0.000)	(0.000)
2018	-0.0134***	-0.00434*	-0.0170***
	(0.000)	(0.046)	(0.000)
Claim type (Fee for service)	0	0	0
	(.)	(.)	(.)
Claim type (Managed care organization)	0.00509***	-0.00375**	0.00658***
	(0.000)	(0.013)	(0.000)
Distance to the nearest MP[1] dentist (< than 0.5 miles)	0	0	0
	(.)	(.)	(.)
Distance to the nearest MP[1] dentist (0.5 -1.0 miles)	0.000421	0.00154	-0.00160
	(0.811)	(0.342)	(0.298)
Distance to the nearest MP[1] dentist (1.0-2.0 miles)	-0.000856	0.00442*	-0.00496**
	(0.656)	(0.012)	(0.003)
Distance to the nearest MP[1] dentist (2.0-5.0 miles)	-0.00144	0.00636**	-0.00606**
	(0.514)	(0.002)	(0.002)
Distance to the nearest MP[1] dentist (>5.0 miles)	-0.0116***	-0.00367	-0.01000***
	(0.000)	(0.101)	(0.000)
Urban RUCA designation	0	0	0
	(.)	(.)	(.)
Large rural RUCA designation	-0.00789***	-0.00624**	0.000928

	(0.001)	(0.003)	(0.635)
Small rural RUCA designation	0.00496	0.00491	0.0106***
	(0.129)	(0.101)	(0.000)
Isolated RUCA designation	-0.00135	-0.00556	0.00394
	(0.752)	(0.156)	(0.282)
No. MP dentists/1,000 HIP Plus enrollees (0-1)	0	0	0
	(.)	(.)	(.)
No. MP dentists/1,000 enrollees (2)	0.0114**	0.0107**	0.0112***
	(0.003)	(0.003)	(0.001)
No. MP dentists/1,000 enrollees (3)	0.0172***	0.0108**	0.0122***
	(0.000)	(0.002)	(0.000)
No. MP dentists/1,000 enrollees (4)	0.0299***	0.0164***	0.0234***
	(0.000)	(0.000)	(0.000)
No. MP dentists/1,000 enrollees (5)	0.0265***	0.0163***	0.0152***
	(0.000)	(0.000)	(0.000)
No. of dentists w/active license/5,000 pop (0-1)	0	0	0
	(.)	(.)	(.)
No. of dentists w/active license/5,000 pop (2)	-0.00171	0.00332	-0.00131
	(0.578)	(0.238)	(0.620)
No. of dentists w/active license/5,000 pop (3)	-0.00467	0.00527	-0.00251
	(0.147)	(0.074)	(0.365)
No. of dentists w/active license/5,000 pop (4)	-0.00281	0.000573	-0.00567
	(0.480)	(0.875)	(0.099)
MP[1] DDS at FQHC[2] (No)	0	0	0
	(.)	(.)	(.)
MP[1] DDS at FQHC[2] (Yes)	0.0124***	0.0110***	0.00934***
	(0.000)	(0.000)	(0.000)
DHPSA[3] designation (No)	0	0	0
	(.)	(.)	(.)
DHPSA[3] designation (Yes)	-0.00704***	0.00100	-0.0137***
	(0.001)	(0.578)	(0.000)
HPSA[4] designation (No)	0	0	0
	(.)	(.)	(.)
HPSA[4] designation (Yes)	0.00126	-0.00798***	0.00818***
	(0.569)	(0.000)	(0.000)

_cons	0.325***	0.228***	0.195***
	(0.000)	(0.000)	(0.000)
lns1_1_1			
_cons	-1.276***	-1.392***	-1.683***
	(0.000)	(0.000)	(0.000)
lnsig_e			
_cons	-0.929***	-0.997***	-0.950***
	(0.000)	(0.000)	(0.000)
N	684156	684156	684156
R^2			

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] – Specific to Healthy Indiana Program (HIP) Plus and HIP State Plan Plus enrollees between Feb. 1, 2015 and Dec. 31, 2018. (N=684,156 person-enrollment years)
[1] Medicaid-participating
[2] Federally Qualified Health Center
[3] Dental Health Professional Shortage Area
[4] Primary Care Health Professional Shortage Area

APPENDIX B:

CHAPTER 3 SUPPLEMENTAL MATERIAL

Table B1: Sensitivity analysis - Fixed effects ordinary least squares regression models predicting the total number of non-preventive visits (NPVs), NPV expenditures, and total dental expenditures among Indiana Medicaid-enrolled adults[a] following preventive dental visits (PDVs) in the prior year

	Total number of NPVs	Total NPV expenditures	Total dental expenditures
	Coeff. (95% CI)	Coeff. (95% CI)	Coeff. (95% CI)
No prior PDV	ref	ref	ref
1 prior PDV	-0.35*** (-0.37, -0.32)	-89.82*** (-94.70, -84.94)	-130.48*** (-137.06, -123.91)
2 prior PDVs	-0.63*** (-0.68, -0.57)	-118.41*** (-130.83, -105.99)	-178.76*** (-191.48, -158.03)
3+ prior PDVs	-1.17*** (-1.31, -1.04)	-189.63*** (-219.16,-160.10)	-267.40*** (-307.17, -227.63)
Constant	9.00*** (7.98, 10.01)	1676.74*** (1449.94, 1903.54)	3231.22*** (2925.79, 3536.37)

Note: All models are adjusted for observed time-varying characteristics, namely age, dental health professional shortage area designation, and year.
ref = Reference category, omitted from model
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018. (N=25,173) – sample restricted to those who had no NPV in first 6 months.

Table B2: Sensitivity analysis - Fixed effects ordinary least squares regression models predicting the total number of non-preventive visits (NPVs), NPV expenditures, and total dental expenditures among Indiana Medicaid-enrolled adults following preventive dental visits (PDVs) in the prior two years

	Total number of NPVs	Total NPV expenditures	Total dental expenditures
	Coeff. (95% CI)	Coeff. (95% CI)	Coeff. (95% CI)
No prior PDV	ref	ref	ref
1 prior PDV	-0.55*** (-0.58, -0.52)	-132.40*** (-139.37, -125.36)	-181.89*** (-191.13, -172.66)
2 prior PDVs	-1.02*** (-1.08, -0.96)	-228.80*** (-242.53, -215.15)	-314.02*** (-332.07, -295.98)
3 prior PDVs	-1.37*** (-1.49, -1.25)	-302.20*** (-329.80, -274.58)	-397.59*** (-433.98, -361.20)
4+ prior PDVs	-2.16*** (-2.38, -1.95)	-424.10*** (-473.38, -374.80)	-562.10*** (-627.06, -497.13)
Constant	10.80*** (9.72, 11.88)	2106.77*** (1858.70, 2354.89)	3954.60*** (3627.56, 4281.63)

Note: All models are adjusted for observed time-varying characteristics, namely age, dental health professional shortage area designation, and year.
ref = Reference category, omitted from model
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018. (N=25,173) – sample restricted to those who had no NPV in first 6 months.

Table B3: **Sensitivity analysis - Fixed effects linear regression models predicting the modal expenditures of all non-preventive visits (NPVs) and total modal expenditures for all dental visits among Indiana Medicaid-enrolled adults[a] following preventive dental visits (PDVs) in the prior year**

	Total NPV expenditures	**Total dental expenditures**
	Coeff. (95% CI)	Coeff. (95% CI)
No prior PDV	ref	ref
1 prior PDV	-92.70*** (-98.68, -86.72)	-128.06*** (-135.60, -120.51)
2 prior PDVs	-121.24*** (-135.50, -106.97)	-168.70*** (-186.70, -150.70)
3+ prior PDVs	-176.09*** (-207.96, -144.21)	-230.95*** (-271.17, -190.73)
Constant	2494.19*** (2196.81, 2791.58)	4378.12*** (4022.83, 4753.40)

Note: All models are adjusted for observed time-varying characteristics, namely age, dental health professional shortage area designation, and year.
ref = Reference category, omitted from model
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018. (N=28,152)

Table B4: **Sensitivity analysis - Fixed effects linear regression models predicting the modal expenditures of all non-preventive visits (NPVs) and total modal expenditures for all dental visits among Indiana Medicaid-enrolled adults[a] following preventive dental visits (PDVs) in the prior two years**

	Total NPV expenditures	**Total dental expenditures**
	Coeff. (95% CI)	Coeff. (95% CI)
No prior PDV	ref	ref
1 prior PDV	-131.52*** (-139.50, -123.55)	-176.03*** (-186.18, -165.88)
2 prior PDVs	-215.37*** (-230.21, -200.53)	-287.70*** (-306.58, -225.82)
3 prior PDVs	-298.56*** (-327.11, -270.00)	-381.20*** (-417.54, -263.87)
4+ prior PDVs	-341.68*** (-388.28, -295.09)	-444.99*** (-504.28, -305.70)
Constant	3086.40*** (2355.58, 3395.85)	5380.25*** (4986.50, 5774.00)

Note: All models are adjusted for observed time-varying characteristics, namely age, dental health professional shortage area designation, and year.
ref = Reference category, omitted from model
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018. (N=28,152)

APPENDIX C:

CHAPTER 4 SUPPLEMENTAL MATERIAL

Table C1: ICD9 Codes CM Dental Diagnostic Codes

520.0	521.5	524.05	524.70	525.67	528.72
520.1	521.6	524.06	524.71	525.69	528.79
520.2	521.7	524.07	524.72	525.71	528.8
520.3	521.81	524.09	524.73	525.72	528.9
520.4	521.89	524.10	524.74	525.73	529.0
520.5	521.9	524.11	524.75	525.79	529.1
520.6	522.0	524.12	524.76	525.8	529.2
520.7	522.1	524.19	524.79	525.9	529.3
520.8	522.2	524.20	524.81	526.0	529.4
520.9	522.3	524.21	524.82	526.1	529.5
521.00	522.4	524.22	524.89	526.2	529.6
521.01	522.5	524.25	524.9	526.3	529.8
521.02	522.6	524.26	525.0	526.4	529.9
521.03	522.7	524.27	525.10	526.5	
521.04	522.8	524.28	525.11	526.61	
521.05	522.9	524.29	525.12	526.62	
521.06	523.00	524.30	525.13	526.63	
521.07	523.01	524.31	524.19	526.69	
521.08	523.10	524.32	525.20	526.81	
521.09	523.11	524.33	525.21	526.89	
521.10	523.20	524.34	525.22	526.9	
521.11	523.21	524.35	525.23	527.0	
521.12	523.22	524.36	525.24	527.1	
521.13	523.23	524.37	525.25	527.2	

521.14	523.24	524.39	525.26	527.3	
521.15	523.25	524.4	525.3	527.4	
521.20	523.30	524.50	525.40	527.5	
521.21	523.31	524.51	525.41	527.6	
521.22	523.32	524.52	525.42	527.7	
521.23	523.33	524.53	525.43	527.8	
521.24	523.40	524.54	525.44	527.9	
521.25	523.41	524.55	525.50	528.0	
521.30	523.42	524.56	525.51	528.01	
521.31	523.5	524.57	525.52	528.02	
521.32	523.6	524.58	525.53	528.09	
521.33	523.8	524.59	525.54	528.1	
521.34	523.9	524.60	525.60	528.2	
521.35	524.00	524.61	525.61	528.3	
521.40	524.01	524.62	525.63	528.4	
521.41	524.02	524.63	525.64	528.5	
521.42	524.03	524.64	525.65	528.6	
521.49	524.04	524.69	525.66	528.71	

Table C2: ICD-10 CM Dental Diagnostic Codes

A69.0	K03.89	K06.1	K08.3	K08.8	K20.0	M26.79
A69.1	K03.9	K06.2	K08.4	K08.9	K20.8	M26.81
B00.2	K04.0	K08.0	K08.40	K09.0	L03.90	M26.82
B00.9	K04.01	K08.1	K08.401	K09.1	M26.00	M26.89
B37.0	K04.02	K08.10	K08.402	K09.8	M26.01	M26.9
B37.9	K04.1	K08.101	K08.403	K09.9	M26.02	M27.1
C80.1	K04.2	K08.102	K08.404	K09.0	M26.03	M27.2
G43.909	K04.3	K08.103	K08.409	K09.1	M26.04	M27.3
G47.63	K04.4	K08.104	K08.41	K11.6	M26.07	M27.4
G89.29	K04.5	K08.109	K08.411	K11.7	M26.09	M27.5
J32.9	K04.6	K08.11	K08.412	K11.8	M26.10	M27.52
K00.0	K04.7	K08.111	K08.413	K12.0	M26.11	M27.53
K00.1	K04.8	K08.112	K08.414	K12.139	M26.12	M27.59
K00.2	K04.9	K08.113	K08.419	K12.2	M26.19	M27.61
K00.3	K04.90	K08.114	K08.42	K12.3	M26.20	M27.62
K00.4	K04.99	K08.119	K08.421	K12.30	M26.211	M27.63
K00.5	K05.0	K08.191	K08.422	K12.31	M26.212	M27.69
K00.6	K05.00	K08.12	K08.423	K12.32	M26.213	M27.8
K00.7	K05.01	K08.121	K08.424	K12.33	M26.220	M27.9
K00.8	K05.1	K08.122	K08.429	K12.39	M26.221	M86.9
K00.9	K05.10	K08.123	K08.43	K13.0	M26.23	Q36.9
K01.0	K05.11	K08.124	K08.431	K13.1	M26.24	S01.512A
K01.1	K05.2	K08.129	K08.432	K13.2	M26.25	S01.54A
K02.3	K05.20	K08.191	K08.433	K13.21	M26.29	S02.5XXA
K02.5	K05.21	K08.13	K08.434	K13.22	M26.30	S02.5XXB
K02.51	K05.221	K08.131	K08.439	K13.23	M26.31	S02.5XXD

K02.52	K05.222	K08.132	K08.49	K13.24	M26.32	S02.5XXG
K02.53	K05.223	K08.133	K08.491	K13.29	M26.33	S02.5XXK
K02.6	K05.3	K08.134	K08.492	K13.3	M26.34	S03.2XXA
K02.61	K05.30	K08.139	K08.493	K13.4	M26.35	S03.2XXD
K02.62	K05.311	K08.19	K08.494	K13.5	M26.36	S03.2XXS
K02.63	K05.312	K08.191	K08.499	K13.6	M26.37	S09.90XA
K02.7	K05.313	K08.192	K08.5	K13.7	M26.39	S09.93XA
K02.9	K05.319	K08.193	K08.50	K13.70	M26.4	T14.90
K03.0	K05.321	K08.194	K08.51	K13.79	M26.60	T18.0XXA
K03.1	K05.322	K08.199	K08.52	K14.0	M26.61	T65.294A
K03.2	K05.323	K08.2	K08.53	K14.1	M26.62	T81.4XXA
K03.3	K05.329	K08.20	K08.530	K14.2	M26.63	T65.294A
K03.4	K05.4	K08.21	K08.531	K14.3	M26.69	T81.4XXA
K03.5	K05.5	K08.22	K08.539	K14.4	M26.7	
K03.6	K05.6	K08.23	K08.54	K14.5	M26.71	
K03.7	K06.0	K08.24	K08.55	K14.6	M26.72	
K03.8	K06.8	K08.25	K08.56	K14.8	M26.73	

Table C3: Sensitivity Analyses - Results of ordinary least squares and instrumental variable regression models estimating the effect of prior or same year preventive dental visit (PDV) on the likelihood of any medical and pharmacy expenditures among Indiana Medicaid-enrolled adults[a] in their third twelve-month period of enrollment

	Percentage change in the likelihood of having any medical expenditures[b] **N=(24,424)** **Coeff. (CI)**	**Percentage change in the likelihood of having any pharmacy expenditures** **(N-24,424)** **Coeff (CI)**
PDV in prior year		
OLS Model	3.4 (2.7, 4.0)***	2.4 (1.5, 3.4)***
IV Model	-1.9 (-11.5, 7.7)	-2.6 (-13.9, 8.7)
PDV in same year		
OLS Model	5.5 (4.8, 6.1)***	5.9 (5.0, 6.8)***
IV Model	12.2 (2.6, 21.7)*	14.4 (3.1, 25.7)*

Note: All estimates are adjusted for gender, race/ethnicity, marital status, living arrangement, family size, year, total number of chronic encounters, total months enrolled, annual well visit, year prior expenditures, RUCA designation, number unemployed, & HPSA designation. Robust standard errors were clustered at the individual level.

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Including pharmacy expenditures

*p<0.05, **p<0.01***p<0.001

Table C4: Sensitivity Analyses - Results of ordinary least squares (OLS) and instrumental variable (IV) regression models estimating the effect of a prior or same year preventive dental visit (PDV) on (logged) medical and pharmacy expenditures among Indiana Medicaid-enrolled adults[a] in their third twelve-month period of enrollment

	Total medical expenditures[b,c] **(N=20,019)** **Coeff. (CI)**	**Total pharmacy expenditures[c]** **(N=16,827)** **Coeff (CI)**
PDV in prior year		
OLS Model	3.3 (0.3, 6.6)*	-5.3 (-9.3, -1.5)**
IV Model	6.6 (-34.3, 52.6)	-4.8 (-40.9, 55.0)
PDV in same year		
OLS Model	8.0 (4.8, 11.3)***	2.9 (-0.8, 6.8)
IV Model	-17.8 (-71.9, 23.9)	-6.4 (-68.2, 48.6)

Note: All estimates are adjusted for gender, race/ethnicity, marital status, living arrangement, family size, year, total number of chronic encounters, total months enrolled, annual well visit, year prior expenditures, RUCA designation, number unemployed, & HPSA designation. Robust standard errors were clustered at the individual level.

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Including pharmacy expenditures

[c] – Conditional on positive expenditures

*p<0.05, **p<0.01***p<0.001

Table C5: Sensitivity Analyses - Results of ordinary least squares and instrumental variable regression models estimating the effect of prior or same year preventive dental visit (PDV) on the likelihood of having any medical and pharmacy expenditures among Indiana Medicaid-enrolled adults[a] in their fourth twelve-month period of enrollment

	Percentage change in the likelihood of having any medical expenditures[b] **N=(20,599)** **Coeff (CI)**	**Percentage change in the likelihood of having any pharmacy expenditures** **(N=20,599)** **Coeff (CI)**
PDV in prior year		
OLS Model	3.5 (2.5, 4.5)***	2.5 (1.4, 3.6)***
IV Model	2.4 (-10.0, 14.8)	-5.8 (-19.3, 7.6)
PDV in same year		
OLS Model	5.0 (4.1, 5.9)***	4.7 (3.5, 5.8)***
IV Model	10.9 (-7.0, 28.8)	13.4 (-6.0, 32.8)

Note: All estimates are adjusted for gender, race/ethnicity, marital status, living arrangement, family size, year, total number of chronic encounters, total months enrolled, annual well visit, year prior expenditures, RUCA designation, number unemployed, & HPSA designation. Robust standard errors were clustered at the individual level.

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Including pharmacy expenditures

*p<0.05, **p<0.01***p<0.001

Table C6: Sensitivity Analyses - Results of ordinary least squares (OLS) and instrumental variable (IV) regression models estimating the effect of a prior or same year preventive dental visit (PDV) on the elasticity of medical and pharmacy expenditures among Indiana Medicaid-enrolled adults[a] in their fourth twelve-month period of enrollment

	Total medical expenditures (logged)[b,c] **(N=15,659)** **Coeff (95% CI)**	**Total pharmacy expenditures (logged)[c]** **(N=13,853)** **Coeff (95% CI)**
PDV in prior year		
OLS Model	-0.2 (-3.9, 3.6)	-7.1 (-11.6, -2.8)
IV Model	-5.1 (-70.7, 54.7)	-40.5 (-144.0, 23.6)
PDV in same year		
OLS Model	1.7 (-2.2, 5.7)	-1.2 (-5.7, 3.3)
IV Model	-37.7 (-154.7. 34.3)	-17.8 (-116.6, 56.0)

Note: All estimates are adjusted for gender, race/ethnicity, marital status, living arrangement, family size, year, total number of chronic encounters, total months enrolled, annual well visit, year prior expenditures, RUCA designation, number unemployed, & HPSA designation. Robust standard errors were clustered at the individual level.

[a] – Specific to Healthy Indiana Program (HIP) Plus enrollees with at least 36 months continuous enrollment between Feb. 1, 2015 and Dec. 31, 2018

[b] – Including pharmacy expenditures

[c] – Conditional on positive expenditures

*p<0.05, **p<0.01***p<0.001

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POSITIONS HELD

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HONORS AND AWARDS

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Indiana Training Program in Public and Population Health Informatics

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2020 IUPUI's *Premier 10* graduate student award
2020 IUPUI's *Elite 50* graduate student award
2016 Honorary Inductee to Sigma Phi Alpha Dental Hygiene Society
- Granted by Indiana University School of Dentistry
2015 Honorary Inductee to Beta Zeta Chapter of Delta Omega
- Granted by Indiana University Fairbanks School of Public Health
2015 Johnson Public Health Faculty Community Service Award
- Granted by Indiana University School of Dentistry

PEER REVIEWED PUBLISHED ARTICLES

1. Mazurenko, O., **Taylor, H.,** Menachemi, N. The impact of narrow and tiered networks on costs, access, quality, and patient steering: A systematic review. *Medical Care Research and Review*. In press.
2. Balio, C., **Taylor, H**., Robertson, A., Menachemi, N. 2021. Faculty salaries in health administration: trends and correlates 2015-2021. *Journal of Health Administration and Education*. In press.
3. Yeager, V., **Taylor, H.,** Menachemi, N., Haut, D., Halverson, P., Vest, J.R. Primary Care Case Conferences to Mitigate Social Determinants of Health: A Case Study from One FQHC System. *American Journal of Accountable Care.* In Press.
4. **Taylor, H**., Brumitt, G., Harle, C., Johnston, A., Williams, K., Vest, JR. Student perceptions of a teaching electronic medical record in Health Administration Education. *Journal of Health Administration Education*. In Press.
5. Bako, A. T., **Taylor, H. L.,** Wiley, K. J., Zheng, J., Walter-McCabe, H. A., Kasthurirathne, S. N., & Vest, J. R. (2021). Using natural language processing to classify social work interventions. The American Journal of Managed Care, 27(1), e24–e31. https://doi.org/10.37765/ajmc.2021.88580
6. **Taylor H**, Holmes AM, Blackburn J. Prevalence of and factors associated with unmet dental need among the US adult population in 2016. Community Dent Oral Epidemiol. 2020 Dec 4. doi: 10.1111/cdoe.12607
7. **Taylor, H.,** Apathy, N., & Vest, J. Health information exchange use during dental visits.* AMIA Annu Symp Proc. 2021 Jan 25;2020:1210-1219. PMID: 33936497; PMCID: PMC8075496.
   **Selected as one of eight finalist papers for AMIA's 2020 Annual Symposium Student Paper Competition (71 total student papers submitted in 2020)*
8. **Taylor, H.,** Rahurkar, S., Treat, T., Thyvalikakath, T. & Schleyer, T. (2020) Does periodontal treatment improve systemic health? A systematic review of reviews. Journal of Dental Research, doi:10.1177/0022034520965958.
9. Blackburn, J., Bennett, A., Fifolt, M., Rucks, A., **Taylor, H**., Wolff, P., Sen, P. (2020) "Pediatric dental care utilization and parent/caregiver-rated oral health among Medicaid enrollees in Alabama, 2019." Journal of American Dental Association 151 (6):416-426. doi.org/10.1016/j.adaj.2020.02.016
10. **Taylor, H.,** Siddiqui, Z., Frazier K., and Thyvalikakath, T. (2019). "Evaluation of a Dental Diagnostic Terminology Subset." Studies in Health Technology and Informatics 264 (August): 1602–3. doi.org/10.3233/SHTI190555

11. **Taylor, H.,** & Yeager, V. A. (2019). Core Competency Gaps among Governmental Public Health Employees With and Without a Formal Public Health Degree. Journal of Public Health Management and Practice: JPHMP. doi.org/10.1097/PHH.0000000000001071
12. **Taylor, H.,** Harle, C., Johnson, S., Menachemi, N. (2019). "Workplace Incivility Experienced by Health Administration Faculty." The Journal of Health Administration Education 36 (2): 191–216.
13. **Taylor, H**. (2016) "Parallels between the Development of the Nurse Practitioner and the Future Advancement of the Dental Hygienist", J Dent Hyg. 2016: 90 (1): 7-9.

ACADEMIC PRESENTATIONS, PROCEEDINGS, ABSTRACTS, & POSTERS

International

1. **Taylor, H**, Zasim Siddiqui, Kendall Frazier, and Thankam Thyvalikakath. 2019. "*Evaluating a Dental Diagnostic Terminology Subset*." Poster Presentation at MEDINFO Annual Conference. Lyon, France (2019).
2. Dixon, BE, Pina, J, Kasthurirathne, S, Harle, C, Kharazzi, H, **Taylor, H.** *Advancing the Health and Wellness for Populations: A Review of Public Health, Population Health, and Global Health Informatics*. Oral Presentation at MEDINFO Annual Conference. Lyon, France (2019)
3. **Taylor, H.** "*Dental Hygiene Masters Program*." Japan Implant Practice – Indiana University Implant Fellow Team. Role: Chair. Tokyo, Japan (2017)
4. Kowolik, M. & **Taylor, H**. "*Dental Professionals Working Together for our Patient's Health*", Oral Presentation at the Annual Japan Implant Practice Society Meeting. Tokyo, Japan (2014).

National

1. **Taylor, H**. & Schleyer, T. *Curing the misinformation epidemic: Time for a better social media platform?,* Oral Presentation at National Library of Medicine Informatics Training Conference. Virtual (2021).
2. **Taylor, H**., Apathy, NC., Vest, JR. *"Health Information Exchange use during dental visits"*. Oral Presentation at AMIA 2020 Annual Symposium. Virtual (2020).
3. **Taylor, H**., Blackburn, J., Bennett, A., Fifolt, M., Rucks, A., Wolff, P., Sen, P. *"Pediatric dental care utilization and parent/caregiver-rated oral health among Medicaid enrollees in Alabama, 2019."* Oral Presentation at AcademyHealth Annual Research Meeting 2020. Virtual (2020).
4. **Taylor, H**., Apathy, NC., Vest, JR. *"Health Information Exchange use during dental visits"*. Oral Presentation at National Library of Medicine Informatics Training Conference. Virtual (2020).
5. **Taylor, H.**, Blackburn, J, & Holmes, A. *Prevalence and predictors of unmet dental need among U.S. adults, 2016.* Poster Presentation at AcademyHealth Annual Conference. Washington, D.C. (2020).
6. **Taylor, H.**, Siddiqui, Z, and Thyvalikakath, T. "*Evaluating a Dental Diagnostic Terminology Subset."* Oral Presentation at the National Library of Medicine Informatics Training Conference. Indianapolis, IN (2019)
7. **Taylor, H.** & Schleyer, T. "*Does treating periodontal disease improve the risk for and outcomes of systemic disease? An opportunity for public health informatics*

research." Poster Presentation at the American Informatics Association Annual Conference . San Francisco, CA (2018)

8. **Taylor, H.** & Schleyer, T. "*Does treating periodontal disease improve the risk for and outcomes of systemic disease? An opportunity for public health informatics research*." Poster Presentation at the National Library of Medicine Informatics Training Conference. Nashville, TN (2018).
9. **Taylor, H.,** Siddiqui, Z., Frazier, K., Thyvalikakath, T. "*Evaluating Content Coverage of a Dental Diagnostic Terminology*", Oral Presentation at the American Medical Informatics Association Annual Meeting. Chicago, IL (2016).
10. Frazier, K., **Taylor, H.,** Siddiqui, Z., Thyvalikakath, T. "*Creating a protocol to evaluate the use of dental diagnostic terminologies*". Poster presentation at the American Association of Dental Research Annual Meeting (2016).
11. **Taylor, H**. "*Implications for e-Learning: Experience and Reflection on Outcomes for U.S. Dental Schools*." Oral Presentation at the American Dental Educators Association, Council of Faculties Meeting. Chicago, IL. (2013).

State/Local

1. Bailey, S., Schlumpf, J., **Taylor, H**. "*Providing Adapted Care for Patients with Immune-Mediated Mucous Membrane Conditions"* Poster presentation at the Indiana University School of Dentistry Research Day. (2015)
2. Borden, S., Brock, J., **Taylor, H**. "*Non-Surgical Periodontal Therapy on a Patient with Uncontrolled Diabetes"* Poster presentation at the Indiana University School of Dentistry Research Day. (2015)
3. Traore, K., Alsalem, A., **Taylor, H**. "*Negative effects of Black Tea on P. Gingivalis*." Poster presentation at the Indiana University School of Dentistry Research Day. (2015)
4. Bentley, E., Bridges, H., **Taylor, H**. "*Non-surgical Periodontal Therapy on a Patient with Advanced Gingival Hyperplasia*." Poster presentation at the Indiana University School of Dentistry Research Day. (2015)
5. **Taylor, H.**, Maxey, H., Stone, C. "*Expanding Access to Dental Care through Dental Hygienists*." Poster presentation at the Indiana University Purdue University Research Day. (2014)
6. Allen, J., Dodgen, N., **Taylor, H**. "*Change in Dental Health Values and Beliefs through Education*." Poster presentation at the Indiana University School of Dentistry Research Day. (2014)
7. **Taylor, H**. & Maxey, H. "*Snapshot of Indiana Dental Hygiene Labor Market*". Poster Presentation at the Indiana University Fairbanks School of Public Health (2014).
8. **Taylor, H.** & Kowolik, J. "*Civic-Minded Dental Professionals.*" Poster Presentation at the IUPUI Robert. G. Bringle Civic Engagement Showcase and Symposium (2013).
9. **Taylor, H.** & Kowolik, J. "*Give Kids a Smile.*" Poster Presentation at the Indiana Joint National Public Health Association – Annual Conference (2013).
10. Kowolik, J. & **Taylor, H**. "*Cavity Free at Three: Is it a Dream?*" Oral Presentation at the Indiana Rural Health Association – Annual Conference (2012).

BOOK CHAPTERS, REPORTS, & OTHER PUBLICATIONS (Non Peer-Reviewed)

1. Acharya, A., Powell, V., Torres-Urquidy, M.H., Posteraro, R.H., Thyvalikakath, T.P. Integration of Medical and Dental Care and Patient Data, *Preface – Integrating Medical and Dental Care: The Role of Informatics in Solving this Challenge* by Titus Schleyer & **Heather Taylor.** 2nd ed., Springer, 2019.
2. **Taylor, H.** (2016). "A Dental Hygienist in All Settings", Dimensions of Dental Hygiene 2016 Supplement: 48-49.
3. **Taylor, H**. "Indiana University School of Dentistry Student Outreach Clinic - A clinical environment of growth, respect, and learning entirely organized and managed by students." ADHA Access. American Dental Hygienists' Association (Jan. 2015).
4. **Taylor, H**. National Children's Oral Health Foundation 2013 Annual Report. IUSD Kids Club/SUAT Activities 2013, Indianapolis, IN.
5. **Taylor, H.** Website article. "IUSD revamps it's Give Kids a Smile Program," Indiana Dental Association News, February 2013, Indianapolis, IN. Retrieved at http://www.indental.org/News/Revamping-Give-Kids-a-Smile
6. **Taylor, H.** Website article. "IUSD Students United for America's Toothfairy Chapter Continues to Grow," May 2013, Retrieved from http://www.ncohf.org/blog/2013/05/15/iusd-students-united-for-americas-125846

SERVICE & COMMITTEE MEMBERSHIP

Professional Service

Activity/Committee	Role	Inclusive Dates
Journal of Public Health Management and Practice	Ad-hoc Peer Reviewer	2020
Journal of Dental Research	Ad-hoc Peer Reviewer	2021
Indiana Oral Health Coalition	Member	2020 - 2013
Indiana Dental Hygienists' Association	Central Component Member	2021 - 2014
Indiana Dental Hygienists' Association	Legislative Committee Member	2021 - 2016
Indiana Dental Hygienists' Association	Immediate Past President	2021 - 2019
American Dental Hygienists' Association	Council on Policy and Bylaws	2020 - 2019
National Alliance and Wound Care and Ostomy	Public Member on Certification Committee	2020 - 2018
AcademyHealth Student Chapter	President	2019
Indiana Dental Hygienists' Association	President	2019 - 2017
American Dental Hygienists' Association	Reference Committee Member	2018
American Dental Hygienists' Association	Research Poster Judge	2016

American Dental Hygienists' Association	Chair – Indiana State Delegation	2016 - 2015
Indiana Dental Hygienists' Association	Three-year National Delegate	2016 - 2015
Indiana Dental Hygienists' Association	HI-PAC Committee Member	2016 - 2014
Indiana Dental Hygienists' Association	President-Elect	2016 - 2017
American Dental Hygienists' Association	Indiana Alternate Delegate	2015 - 2014

Professional Associations

Organization	Inclusive Dates
AcademyHealth	Present - 2018
American Dental Education Association	2016 - 2013
American Dental Hygienists' Association	Present – 2004
American Medical Informatics Association	Present - 2015
American Public Health Association	2017 - 2015
Beta Zeta Chapter of Delta Sigma (Public Health)	Present - 2015
Central Indiana Dental Hygienists' Association	Present – 2011