Abstract

Background: Dental caries, commonly known as tooth decay, is one of the most prevalent chronic diseases in the United States despite being largely preventable. Early childhood caries (ECC) are particularly detrimental to pediatric health and are more prevalent among children of lower socioeconomic status, presenting a problem to poorer states with a low dentist-to-population ratio such as North Carolina (NC). Into the Mouths of Babes (IMB) is an NC program that addresses ECC and dentist shortage by reimbursing physicians for administering preventive dental treatments and providing oral health education to children enrolled in Medicaid.
Objective: This study determines the effect of distance a child must travel to an IMB provider on utilization of IMB services, controlling for dentist utilization and demographic factors. **Data sources**: Claims data from 2013 to 2015 for children who utilized IMB services in North Carolina. **Methods**: This retrospective longitudinal study used data provided by North Carolina Division of Medical Assistance (NC-DMA), the organization that administers Medicaid in NC. A zero-truncated Poisson regression model was used to determine the effect of distance to an IMB provider on number of IMB visits, while including dentist visits, age at first IMB visit, race, ethnicity, and gender as predictors. **Results**: Distance travelled to an IMB provider slightly decreased IMB utilization. The most influential predictor of IMB utilization was a child's utilization of dental services. Demographic factors such as race and ethnicity were related to IMB utilization. **Conclusions**: These results show that there is a substantial relationship between dentist visits and utilization of IMB services; future research should investigate this relationship. Travel distance does not appear to be an influential barrier to IMB participation, so NC-DMA and state policymakers should consider focusing on reducing other barriers to pediatric access to IMB services.

Problem Description & Significance

Dental caries, commonly known as tooth decay, affects 92 percent of adults ages 20 to 64. Caries prevalence in recent years has decreased among adults, but it continues to increase and remains the most prevalent chronic disease among children. Effects of childhood caries include tooth loss requiring treatment by a dentist, severe weight loss due to oral pain and reduced metabolism, and missed school days. More seriously, if left untreated caries can result in early childhood death due to bacteria from a tooth abscess spreading to a child's brain.

Despite being largely preventable through proper oral hygiene and regular dental exams, almost 60 percent of American elementary school children from 2011 to 2012 had caries experience in primary or permanent teeth. There are many risk factors that influence childhood caries development, but perhaps the most salient is socioeconomic status; children of low socioeconomic status experience caries at an earlier age and at a higher rate.

Dentists and physicians can prevent caries development through fluoride varnish treatments. Research shows fluoride varnish is safe, effective at preventing caries, and cost saving due to avoiding expensive dental treatments associated with untreated caries. However, some children in states such as North Carolina (NC) face barriers to obtaining fluoride varnish. NC has the fourth worst dentist-to-population ratio nationwide, and seven counties have one or fewer dentist to serve the county's population. NC also ranks 34th in poverty, with approximately 1.2 million children enrolled in public insurance such as Medicaid or NC's Children's Health Insurance Plan.

Dentist participation in public insurance is low – less than 40 percent of dentists statewide actively participate, and four counties have no dentist accepting public insurance. Dentists who do participate in public insurance face reimbursement anywhere from 44 to 58

percent of the national average, therefore little incentive exists to provide care for children on public insurance.

Into the Mouths of Babes (IMB) is a program implemented by NC's Division of Medical Assistance designed to address oral health among low-income children and the dental provider shortage across rural regions of the state. The program educates medical providers on the importance of oral health, how to assess childhood oral health, and how to administer fluoride varnish to children. Additionally, the program provides reimbursement to medical providers through Medicaid. Since low-income children in rural areas face poor oral health compounded by a shortage of dental providers, allowing medical providers to administer a preventive dental treatment increases childhood access to dental care.

Results of IMB have largely been positive. From 2000 to 2006, approximately 30 percent of the 630,000 Medicaid-enrolled children ages six to 35 months received oral health medical visits through IMB. Children receiving at least four IMB visits experienced a 17 percent reduction in caries-related treatments. Additionally, utilization was highest in rural counties; a lower dentist-to-population ratio increased the likelihood of child and medical provider participation. IMB providers faced barriers to program implementation including staff and colleague resistance, difficulties integrating the dental treatments into normal clinical practice, and low availability of local dentists for referrals.

Problem Statement

There is currently no research regarding barriers children experience to IMB participation. While IMB is targeted at children who lack access to a dentist, children may also face geographic, logistical, or financial barriers to visiting a medical provider for IMB visits. Therefore, there is a need to identify factors limiting child access to IMB treatments.

Research question

How is geographic distance to an IMB-participating medical provider associated with the level of IMB utilization among Medicaid-enrolled children in NC?

Review of the Literature

Dental caries is the most prevalent chronic disease among children, is experienced more frequently by children in low-income households, and is preventable through application of fluoride varnish.

Dental caries, commonly known as tooth decay, is one of the most prevalent chronic diseases in the United States.[1] Ninety-two percent of adults ages 20 to 64 have had caries in their permanent teeth.[2] Caries can form at any stage of life, and are caused by the interaction of oral bacteria, host saliva, and carbohydrate fermentation.[3] While caries prevalence has decreased among adults in recent years, it continues to increase and remains the most prevalent chronic disease among children.[4,5] The obvious effects of childhood caries are acute tooth pain and tooth loss requiring treatment by a dentist. However, less apparent long-term effects include missed school days, severe weight loss due to oral pain and reduced metabolism, impaired cognitive development, and foregone parental wages due to trips to the dentist.[6,7] In rare cases, caries can result in early childhood death; one example is Deamonte Driver, the twelve-year-old boy who died due to bacteria from a tooth abscess spreading to his brain.[8]

Although 57.7 percent of American elementary school children from 2011 to 2012 had caries experience in primary and permanent teeth, caries is largely preventable through proper oral hygiene, an appropriate diet, fluoride varnish, and regular dental exams and cleanings.[9,10] However, these individual interventions greatly depend on one's self-efficacy, sociodemographic status, and personal value of health prevention.[11] In conjunction with these individual influences, family, community, race, culture, and ethnicity have an impact on caries development.[12] For

example, children of low socioeconomic status experience early childhood caries (ECC) at a higher rate and at an earlier age, putting even more of a burden on financially strained parents.[13]

Early detection of ECC is critical, as prompt intervention by a dentist may prevent painful and expensive surgeries later in a child's life.[14] Additionally, ECC is reversible when diagnosed at an early age.[15] Children who see a dentist regularly have fewer caries and better oral health than children who do not.[16] One way dentists and physicians prevent ECC is through fluoride varnish treatments. Numerous studies have shown that childhood fluoride varnish is an effective measure in preventing caries, and that there may be a dose-dependent relationship between fluoride varnish and caries development.[17,18,19] Weintraub et al. found that children who did not receive fluoride varnish had twice the odds of developing caries than those who received fluoride varnish once a year, and almost four times the odds compared to children who received fluoride varnish twice a year.[20] Fluoride varnish is safe and generates cost-savings, as it is relatively inexpensive compared to the surgical and restorative solutions for untreated ECC.[21] However, there are significant barriers to obtaining fluoride varnish for certain populations. For example, states such as North Carolina (NC) where some counties have no dentist and residents rely heavily on public assistance programs such as Medicaid face geographic, financial, and access barriers to obtaining preventive dental services.

For NC children in low-income households, there is lack of dental access due to provider shortage, reliance on public insurance, and low provider reimbursement rates.

Children in NC experience barriers to accessing and paying for dental care. NC has the fourth worst dentist-to-population ratio nationwide, and in 2011 there were 4.3 dentists per 10,000 as compared to the national average of 5.8.[22] In addition, seven counties in NC have one or no dentist in the county.[23] Compounding the lack of dental care access, the state ranks 34th in poverty.[24] Thus, residents have problems both reaching and paying for care.[25] This presents an

issue for children in NC, as poor access and low socioeconomic status are risk factors to caries development.[26]

Many children in NC rely on public insurance, but low utilization, provider participation, and reimbursement create oral health disparities. Children in NC with household incomes of up to 211 percent of the federal poverty line are eligible for Medicaid or NC Health Choice, the state's Children's Health Insurance Plan (CHIP).[27] These public insurance programs provide dental coverage for approximately 1.2 million children living in poverty statewide.[28] However, utilization of the preventive services required to avoid oral diseases such as dental caries is poor – between 42 and 45 percent of children enrolled in a public insurance program received any preventive dental services in 2011.[29] Dentist participation in these public payer programs is low – less than 40 percent of the 4,600 practicing dentists statewide actively participate, and four counties have no dental providers accepting public insurance.[30] Low dentist participation is a result of broken appointments, patient noncompliance, and burdensome paperwork, but the most salient factor is likely low provider reimbursement rates.[31]

Sixty-two percent of dentist revenues on average go towards provider overhead (rent, staff wages, clinical supplies), but Medicaid and NC Health Choice payments for preventive dental services are anywhere from 44 to 58 percent of the national average.[32,33] Dental providers in NC may not be able to cover their overhead costs when accepting public insurance, therefore little incentive exists to provide care for children on public insurance. As 31 percent of children had decay in primary teeth and 13 percent experienced decay in permanent teeth, these barriers to dental care must be addressed to improve the oral health of children in NC.[34,35]

Into the Mouths of Babes is a statewide program that provides fluoride varnish and oral health education for low-income children at their regular medical provider.

Significant statewide efforts to increase primary prevention of dental caries began in the mid-1990s. The North Carolina Partnership for Children created Smart Smiles to address low-income preschool children's poor oral health in the western Appalachian part of the state, containing counties with up to 66 percent pediatric caries prevalence.[36] Barriers to dental care in this part of the state included a 16 percent dentist participation in Medicaid and a 10 percent utilization of dental services by child Medicaid enrollees.[37] Smart Smiles was a grant-funded demonstration program that utilized five dental hygienists to develop oral health interventions specific to the children in their regions.[38] All five hygienists recognized that low-income children in Western NC could access primary care providers (PCPs) better than dental providers, so interventions were directed at PCP provision of oral health screening, education, and preventive services. Private medical practices and local health departments provided caries screening, oral health education, and application of fluoride varnish to at-risk children up to three years old.[39] Preventive services were delivered at over 3,000 visits when the program concluded in 2001. Success with the program was attributed to the multidisciplinary approach to community health and the integration of the program into the existing medical care delivery system.[40]

Success of the Smart Smiles program led to the creation of a pilot study to gauge feasibility of a statewide intervention. NC Division of Medical Assistance (NC-DMA), the agency that administers Medicaid in NC, recruited practitioners in 66 medical offices to participate in a pilot continuing medical education (CME) course. The course was designed to educate medical providers about oral health and preventive dental care; it provided feedback to NC-DMA regarding the training efficacy and statewide adaptability.[41] Using results and feedback from the pilot program, a statewide initiative was created and funded by NC-DMA,

Centers for Medicare and Medicaid Services (CMS), Health Resources and Services

Administration (HRSA), and the Centers for Disease Control and Prevention (CDC).[42]

Known as Into the Mouths of Babes (IMB), the statewide program has two main

components critical to its success: a CME course teaching oral health screening, fluoride varnish

application, and child oral health education, and medical provider reimbursement for preventive

dental services.[43] Physicians or physician extenders are reimbursed for up to six medical visits

for children under the age of three.[44] Participating providers are reimbursed by NC-DMA if their

visits satisfy IMB's three-component approach to ECC prevention: oral health screening,

assessment, and referral to dentist if necessary, application of fluoride varnish to child's teeth,

and health education of primary caregivers regarding child oral health.[45] Oral health screening

consists of a visual inspection of the oral cavity, and a patient encounter form to identify child

risk factors for ECC.[46] Samples of fluoride varnish are provided initially to IMB providers, and

IMB provides a list of which vendors to purchase future supplies from. The CME toolkit

provided through the program contains educational handouts for parents as well as information

for dentist referrals. By 2006, all 100 counties in NC had at least one IMB provider.[47]

IMB results have been mixed at the child and provider level; children with at least four visits had a significant reduction in caries, but physicians faced barriers to referring children to a dentist for further treatment.

From 2000 to 2006, roughly 30 percent of the approximately 630,000 Medicaid-enrolled

children ages six to 35 months received oral health medical visits through IMB.[48] Visits were

most frequent at the IMB-recommended ages of 9, 12, 15 18, and 24 months.[49] Between

approximately 30 percent of all participating children had at least one fluoride varnish

application, compared to 2.5 percent of children nationally receiving fluoride varnish.[50] A lower

dentist to population ratio increased the likelihood that a child would participate in IMB, and

increased the likelihood of medical provider participation.[51] Additionally, utilization was highest in rural counties.[52] Pahel et al. found children with ≥4 IMB visits received 17 percent fewer dental treatments related to caries compared to children with no IMB visits.[53] The reductions in caries-related treatments varied with age and number of IMB visits. There was no statistically significant reduction in caries-related treatments among children with three or fewer IMB visits, and so at least four visits were required to observe an effect on caries.[54]

Results of IMB are consistent with literature. A meta-analysis of 10 clinical trials found a 37 percent decrease in caries among children who received fluoride varnish applications between two and four times a year.[55] Slade et al. found between a 24 and 36 percent reduction in caries among children who received fluoride varnish application twice a year for two years.[56] Pahel et al. described a *threshold effect* where at least four visits were required to observe a significant reduction in caries; previous studies are moderately consistent with these findings. Weintraub et al. found a dose-dependent relationship between number of fluoride varnish applications and caries reduction beginning at the first application, indicating there is no threshold effect.[57] However, an observational study by Holve found that children with at least four fluoride varnish applications had a caries reduction of 35 percent, but children with fewer than four applications had no significant caries reduction.[58] Discrepancies in results may be due to IMB study design (observational vs. randomly controlled trial) and differences in caries prevalence in study populations.[59] Additionally, using number of caries-related treatments as the outcome measure instead of caries incidence may have underestimated the effectiveness of IMB, as not every child who received fluoride varnish application followed up later with a dentist for treatment.[60]

From the provider perspective, participation in IMB has been positive. Over 70 percent of IMB providers provided preventive dental services on a regular basis.[61] A majority of IMB

providers reported that they were likely to refer children to a dentist upon screening, and over half of providers called a dental office personally to schedule an appointment for the child to be referred.[62] The most common method of referral was providing the child's parents with a dentist's name.[63] IMB providers identified barriers to program adoption including difficulties in applying fluoride varnish, staff resistance, and integrating the dental treatments into normal clinical practice.[64] Providers were clinically accurate in their caries screening and identification, but faced significant barriers in referring patients to dentists.[65,66] Providers cited the low availability of dentists as a major barrier to referrals; likelihood of referral was correlated more strongly with availability of dentists than provider knowledge, experience, or opinion.[67]

No studies, however, have analyzed barriers to child participation in IMB. Children seeking dental care from IMB providers may face geographic, logistical, or financial barriers to visiting the provider. In order for IMB to effectively address childhood caries in NC, such barriers must be identified and overcome. Therefore, there is a need to identify factors affecting child access to and utilization of IMB treatments. Many studies have reported that distance to an outpatient medical provider negatively affects patients' level of medical service utilization.[68,69] However, to this author's knowledge, there are no studies that assess the effect of distance to a pediatric medical provider on utilization of preventive dental services through a program such as IMB. By analyzing the effect of distance to an IMB-participating medical provider on level of IMB utilization, this study will inform the NC Division of Medical Assistance as well as policymakers on how best to use their resources to address the oral health of the low-income pediatric population of NC.

Research Design

This study utilized a retrospective longitudinal design to assess influences on healthcare utilization over a period of time. Through a secondary data analysis, geographic information system (GIS) mapping technology along with R Statistical Programming Language (www.r-project.org, Version 3.2.4) was used to analyze existing North Carolina Division of Medical Assistance (NC-DMA) claims data for IMB-participating children from 2013 to 2015.

Research Methods & Data Sources

Patient data from 2013 to 2015 was abstracted from electronic claims provided by NC-DMA. Each claim represents a provider billing NC-DMA for either or both procedure codes (D0145 & D1206) associated with IMB. Claims were de-identified; consistently masked IDs for both the provider and patient were assigned to each claim. The dataset contained month and year of service, patient ID, provider ID, straight line distance between patient and provider in miles, number of non-IMB dental visits (HCPCS codes D0100-D9999) made to non-IMB providers in the month of service, race, ethnicity, sex, age at time of provider visit, and precision of provider and patient locations. Addresses of patients and IMB providers were converted to latitude and longitude using street-level geocoding in SAS (SAS Institute, Cary, NC). When street-level geocoding failed, the program defaulted to zip code- or city-level determination. Proximity to provider was calculated using SAS by finding the Euclidian (straight line) distance between a patient's residence and provider's office based on latitude and longitude. While travel time is the most likely determinant of healthcare utilization, straight-line distance is a robust proxy and can therefore be used.[70]

Participants & Sampling Methods

This research focused specifically on children enrolled in either Medicaid or NC Health Choice for Children who had at least 1 visit to a provider participating in the IMB program between 2013 and 2015. The original dataset contained 210,354 records (individual IMB visits) from 93,640 children from 2013 to 2015. The dataset was cleaned by removing 1,851 claims of children who were not between the ages of 0 and 42 months at the time of their visit, the age range allowed under IMB. This resulted in a total sample size of 208,503 visits across 92,496 children.

Data Analysis Methods

Statistical analysis was performed using open-source R software.[71] A zero-truncated Poisson (ZTP) regression was used to assess the relationship between distance to an IMB-participating medical provider and the level of IMB utilization among children enrolled in Medicaid or NC Health Choice for Children, after controlling for possible covariates. ZTP regression is useful to model count data where the value zero cannot occur.[72] Significance was considered at p<0.05.

The influence of each explanatory variable (distance travelled to provider visit [continuous], number of non-IMB dental visits in the IMB visit month [continuous], age at first IMB visit between 2013 and 2015 [continuous], race [reference: white], ethnicity [reference: not Hispanic/Latino], and sex [reference: male]) on number of IMB visits (count) was assessed with the model.

Ethical Considerations

Institutional Review Board (IRB) approval was obtained at the University of North Carolina at Chapel Hill for this study (IRB Study #16-0230). A confidentiality agreement as well as a data release form between the researcher and NC-DMA were obtained.

Instruments

R code for the statistical analysis is included in the Appendix.

Results

Descriptive Statistics of Study Population

Table 1 summarizes the demographic makeup of the 92,496 children who visited an IMB medical provider between January 1, 2013 and December 31, 2015 and were under 42 months old at the time of visit. The total number of IMB visits for the study population was 208,503. The largest demographic groups were male, white, and not Hispanic/Latino. The largest proportion of visits came from children ages 19 to 24 months old. The first IMB visit between 2013 and 2015 for these children tended to be between ages 7 and 12 months old. It is important to note that the study population likely had IMB visits before 2013, but these were not captured in the claims data starting January 1, 2013. Therefore, "Age at First Visit from 2013 to 2015" in Table 1 represents the study population's ages at the first IMB visit recorded between January 1, 2013 and December 31, 2015, not necessarily the age at their first IMB visit.

Table 1. *Demographic characteristics of children participating in IMB from 2013-2015*

Characteristics	IMB Beneficiaries January 2013 – December 2015 n = 92,496	
	Counts (n)	Percents (%)
Sex		
Female	45,470	49.16
Male	47,026	50.84
Race		
Asian	2,126	2.3
Black	36,389	39.34
American Indian	2,613	2.82
Hawaiian or Pacific Islander	168	0.18
White	49,666	53.70
Unreported	1,534	1.66
Ethnicity		
Hispanic Cuban	569	0.62
Hispanic Other	14,976	16.19
Hispanic Mexican American	5,365	5.80
Not Hispanic/Latino	58,103	62.82
Hispanic Puerto Rican	169	0.18
Unreported	13,314	14.39
Total Visits per Age Group		
0-6 months old	2,986	1.43
7-12 months old	42,894	20.57
13-18 months old	55,219	26.48
19-24 months old	46,771	22.43
25-30 months old	25,835	12.39
31-36 months old	20,813	9.98
37-42 months old	13,985	6.71
Age at First Visit from 2013-2015		
0-6 months old	2,959	3.2
7-12 months old	30,219	32.67
13-18 months old	20,066	21.69
19-24 months old	14,976	16.19
25-30 months old	9,113	9.85
31-36 months old	8,438	9.12
37-42 months old	6,725	7.27

Table 2 shows the number of IMB visits, number of non-IMB dental visits, and average distance travelled to an IMB provider for the study population, separated by sex, race, and ethnicity. Note here that "Non-IMB dental visits" were defined in the study data as a visit to a

dental provider that billed NC-DMA for HCPCS (Healthcare Common Procedure Coding System) codes D0100-D9999 in the same month a child had an IMB visit. Visits to a dentist were only captured in the study data if it occurred in the same month as an IMB visit. Therefore, the number of non-IMB dental visits represents the number of visits to a dentist in the 3-year period that occurred in the same month as an IMB visit, not necessarily the total number of dentist visits in the 3-year period. While this isn't an accurate characterization of the total number of dentist visits by children in the study period, it was nevertheless included to assess the relationship between visiting a dentist and visiting an IMB provider in the same month.

Taking an initial look at the utilization data summarized in Table 2, the study population had an average of 2.25 IMB visits in the 3-year period, and travelled an average of 8.85 miles to an IMB provider. The average number of both IMB and non-IMB dental visits were similar between females and males, while females tended to travel slightly farther to an IMB provider. In terms of race, Asians and Hawaiian/Pacific Islanders tended to have more IMB visits and non-IMB dental visits, while black children had the lowest number of IMB/non-IMB visits. While Hawaiian/Pacific Islander children tended to have higher utilization of IMB and non-IMB services, they also traveled the farthest on average to an IMB provider.

Table 2. *IMB Utilization, Non-IMB Dental Visits, and Distance Travelled to IMB Provider by Demographic Characteristic*

	Demographic Characteristic	IMB visits n=208,503			Non-IMB dental visits n=8,530			Distance travelled to IMB provider (miles)		
		n	**%**	$\overline{x}$	**n**	**%**	$\overline{x}$	**n**	**%**	$\overline{x}$
SEX	Female	101941	48.89%	2.24	4149	48.64%	0.091	-	-	8.77
	Male	106562	51.11%	2.26	4381	51.36%	0.093	-	-	8.68
RACE	Asian	5260	2.52%	2.47	283	3.32%	0.133	-	-	8.43
	Black	79767	38.26%	2.19	3004	35.22%	0.082	-	-	8.12
	American Indian	6365	3.05%	2.43	232	2.72%	0.088	-	-	9.16
	Hawaiian or Pacific Islander	414	0.20%	2.46	23	0.27%	0.136	-	-	9.46
	Unreported	3468	1.66%	2.26	201	2.36%	0.131	-	-	7.74
	White	113229	54.31%	2.27	4787	56.12%	0.096	-	-	9.16
ETHNICITY	Hispanic Cuban	1254	0.60%	2.20	36	0.42%	0.063	-	-	9.76
	Hispanic Other	34424	16.51%	2.29	2194	25.72%	0.146	-	-	7.39
	Hispanic Mexican American	12680	6.08%	2.36	738	8.65%	0.137	-	-	8.32
	Not Hispanic/Latino	130802	62.73%	2.25	4562	53.48%	0.078	-	-	9.02
	Hispanic Puerto Rican	373	0.18%	2.20	15	0.18%	0.088	-	-	7.49
	Unreported	28970	13.89%	2.17	985	11.55%	0.073	-	-	9.14

Table 3 shows the percentages of the population that had to travel various distances to their IMB visit. Over 70 percent of the study population travelled less than 10 miles to an IMB provider. Less than 3 percent of children had to travel more than 30 miles to an IMB provider.

Table 3. Average Distance Study Population Travelled to
IMB Provider

Average Distance Travelled (miles)	IMB visits n=208,503		
	n	%	Cumulative %
<1	4658	5.04%	5.04%
1 - 5	36175	39.11%	44.15%
6 - 10	25161	27.20%	71.35%
11 - 20	18173	19.65%	91.00%
21 - 30	5633	6.09%	97.09%
>30	2696	2.91%	100.00%

Zero-Truncated Poisson Regression Model

The results from the zero-truncated Poisson regression are summarized below in Table 4. As the Poisson regression is a log-linear model, slope estimates (β) were exponentiated (e^β) to find the multiplicative changes in the number of IMB visits for each one-unit change in predictors. The average distance the study population had to travel to an IMB visit was found to significantly influence the number of IMB visits in the 3-year study period. Keeping all other predictors constant, increasing the distance from an IMB provider by 1 mile slightly decreased the expected number of IMB visits by 0.1 percent. To put this in context, the model predicts that a child that living 20 miles away from an IMB provider would have approximately 2 percent fewer visits than a child living less than a mile from the provider.

The number of non-IMB dental visits and a child's age at first IMB visit between 2013 and 2015 were more influential predictors on number of IMB visits. Keeping other predictors constant, a one-unit increase in the number of non-IMB dental visits increased the expected number of IMB visits by 20.8 percent. The model predicts that a child who regularly visited a dental provider during the 3-year study period (regular defined as one visit every 6 months)

would have more than 3 times the number of visits than a child who did not visit a dental provider at all during the study period. In terms of a child's age at the first recorded visit in the study period, a one-month increase in the child's age decreased the expected number of IMB visits by 9.3 percent. The model predicts that a child whose first recorded IMB visit in the study period was at 12 months old would have approximately 70 percent fewer visits than a child whose first recorded IMB visit was at 0 months old.

While sex did not significantly predict the number of IMB visits, race and ethnicity were significant predictors in the model. Asian and American Indian children had 12.3 percent and 13.1 percent more IMB visits, respectively, compared to the white reference group. Additionally, children who identified as either "Hispanic Other" or "Hispanic Mexican American" had approximately 5 percent more visits than the "Not Hispanic/Latino" reference group. Children with unreported ethnicities had 2.8 percent more visits in the study period than the reference group as well.

Table 4. Zero-truncated Poisson regression model of number of IMB visits adjusted for average distance from IMB provider, number of non-IMB visits, age at first IMB visit, sex, race, and ethnicity

		Coefficients (β)	Log-transformed Coefficient ($e^β$)	*p*-value
	Distance from IMB Provider	-0.001	0.999	<.001*
	Number of non-IMB visits	.0.189	1.208	<.001*
	Age at first IMB visit	-0.098	0.907	<.001*
Against male as reference value	Female	0.003	1.003	.614
Against white as reference value	Asian	0.116	1.123	<.001*
	Black	-0.001	0.999	.850
	American Indian	0.123	1.131	<.001*
	Hawaiian or Pacific Islander	0.089	1.093	.125
	Unreported	0.028	1.029	.183
Against not Hispanic/Latino as reference value	Hispanic Cuban	-0.010	0.990	.774
	Hispanic Other	0.048	1.050	<.001*
	Hispanic Mexican American	0.050	1.051	<.001*
	Hispanic Puerto Rican	0.013	1.013	.844
	Unreported	0.027	1.028	<.001*

*significant at α=0.05

Discussion

The purpose of this study was to analyze the relationship between the distance a pediatric Medicaid population had to travel to receive an IMB visit and their subsequent utilization of IMB services in NC. The average distance travelled to an IMB provider was found to significantly decrease the predicted number of IMB visits in the study period, even when controlling for individual demographic characteristics and utilization of non-IMB dental services. However, the decrease in the number of IMB visits was small, with a 20-mile increase in child-to-provider distance yielding only a 2 percent decrease in IMB utilization. This is

somewhat consistent with a previous study that found that distance to a provider was significantly related to utilization of regular medical checkups.[73] Since distance travelled only slightly influenced the number of visits, proximity to an IMB provider may not be a substantive barrier to IMB utilization for this study population.

The number of non-IMB dental visits in the study period was found to be significantly positively associated with the number of IMB visits in the study period. Children who had more visits from dentists tended to have a higher utilization of IMB services. However, this model cannot assess the temporal relationship between dental visits and IMB utilization. One possibility is that a child first visited a dentist who referred the child to an IMB provider based on a medical need. Another possibility, perhaps more likely, is that when children visited an IMB provider, they presented with an oral healthcare need that could only be addressed by a dentist, so the IMB provider referred them appropriately. Since the study data only counted dentist visits in the same month as IMB visits and did not include which visit happened first, a directional relationship cannot be established. This is obliquely consistent with existing literature; to this authors knowledge there have been no studies reporting on the relationship between dental visits and medical visits among children. However, among an elderly population, Atchison et al. found that recent dental visits were significantly associated with an increase in utilization of other health services.[74]

A child's age at their first IMB visit between 2013 and 2015 had a significant negative association with number of IMB visits; a one-month increase in age at first IMB visit decreased the predicted number of visits by 9.3 percent. The IMB program only will reimburse medical providers for preventive dental services for children aged 0 to 42 months. This data suggests that the younger a child was at their first visit between 2013 and 2015, the more subsequent visits

they had. This is logical because younger children (closer to 0 months old) were enrolled for a greater proportion of the study period than older children (closer to 42 months old), and therefore had more opportunities to have an IMB visit.

Individual demographic characteristics also influenced IMB utilization. While sex did not have a significant influence on number of IMB visits, certain aspects of race and ethnicity did have an effect. Compared to white children, Asian and American Indian children had significantly more IMB visits on average. In terms of ethnicity, children who identified as "Hispanic Mexican American" and "Hispanic Other" had significantly higher utilization of IMB services with "not Hispanic/Latino" as the reference group. Andersen et al. found that race and ethnicity were moderate predictors of utilization of both physicians and dentists.[75] Somewhat contradicting the findings of this study, a literature review by Flores found that African American, Asian American, American Indian, and Hispanic American children experienced extensive disparities in terms of health outcomes and access to and utilization of physician services.[76] While this study did not assess the health outcomes of the study population, the results of this study contradict previous literature suggesting Asian, American Indian, and Hispanic have lower utilization of health services. However, it is important to note that the study population represented a unique population in NC of children who were enrolled in a social health insurance program (Medicaid/NC Health Choice) and participated in a program providing preventive dental care at medical offices (IMB), and therefore may not be wholly representative of the entire American population that other studies have reported on.

Limitations and Opportunities for Future Research

There are several limitations inherent to this study due to the source of data and the methods of data analysis. Retrospective longitudinal study designs do not allow determination of

causality between the exposure (distance to IMB-participating medical provider) and the outcome variable (number of IMB visits). Additionally, some data that would be ideally controlled for were not captured in the claims data. For example, children receiving fluoride varnish from a school-based program or mobile community dental clinic may not seek preventive dental services from IMB, potentially resulting in an overestimation of the effect of distance on utilization. This information would not be captured in claims data, so cannot be controlled for.

Another limitation to consider is the precision of the patient-provider distance calculation. Not every claim in the data set had an address-address match between the child and IMB provider. Over 90 percent of IMB visits could be matched to a specific provider address, and approximately 80 percent of visits could be matched to a specific patient address. Approximately 70 percent of all claims had the most precise, address-address match between a child and provider. Visits without an address match required researchers to assign provider or patient geocodes to visits either based on city of residence or 5-digit zip code, which are inherently less precise than an address. The least precise geocoding matches (zip code-zip code, city-city, zip code-city, and city-zip code) made up approximately 2 percent of all records.

Additionally, the dataset contained some outlier data, with distances over 300 miles. It is unknown whether those outlier distances actually represent a proxy for the distance a child's parent or guardian had to drive for an IMB provider visit, or if the child was staying with a friend or relative, or was out of town and had to visit an IMB provider. Since this could not be assessed with the available data, and ground-truthing was not possible due to confidentiality requirements, the data was not excluded from analyses.

Another limitation of this study involves the data analysis. Due to time constraints and capabilities of the author, a zero-truncated Poisson regression model was chosen to assess the influence of proximity to an IMB provider and IMB utilization. However, there may be more advanced and precise methods that give a more accurate representation of the relationship between distance, utilization, and the covariates assessed in this study. A zero-truncated negative binomial regression may be a better model for this data, particularly if assumptions of the Poisson model are not strong.[77] With more time, more advanced statistical techniques such as this could be used to increase accuracy of the results.

One final limitation to consider is that distance to IMB-participating medical provider was measured using the straight-line method as opposed to travel time on roads. This method has been shown to be a reasonable proxy for travel time in hospital demand models, but it may not be accurate when dealing with a dense urban areas involving reliance on walking.[78] Moreover, the claims data do not include whether or not the family has access to a car, so whether a child and/or parent walked or used public transportation to an IMB provider is unknown. Further research on this subject may examine the relationship between family ownership of a car and utilization of IMB services to identify how to increase access and utilization.

Conclusion

This study has shown that an increase in travel distance is associated with a slight decrease in the number of IMB visits in a 3-year period. More influentially, children who see a dentist regularly have over 3 times as many IMB visits than children who do not. Additionally, racial and ethnic differences exist among children in terms of IMB utilization. While distance to an IMB provider was identified as a modest barrier to IMB utilization in this study population, there is a substantial relationship between dentist visits and utilization of IMB services. Further

research should analyze the relationship between dentist and IMB visits to assess if IMB visits are driving dental visits, or if the opposite is more likely. As travel distance does not appear to be an influential barrier to IMB participation, North Carolina Division of Medical Assistance as well as state policymakers can more effectively marshal and direct their resources towards reducing other barriers to pediatric access to IMB services. The results of this study can inform various stakeholders regarding pediatric access to preventive oral health care at medical offices through the IMB program.

Appendix

```
# Code used for data analysis in R

#load required packages
install.packages("foreign")
install.packages("ggplot2")
install.packages("VGAM")
install.packages("boot")
library("foreign")
library("ggplot2")
library("VGAM")
library("boot")

#upload claims data file into R and defines variables
PoissonData=read.csv("Claims Data Here",header=T)
attach(PoissonData)

#zero-truncated Poisson regression: Number of IMB visits on average distance to provider,
 number of non-IMB dental visits, age at first IMB visit between 2013 and 2015, race, ethnicity,
 and gender
PoissonTest <- vglm(NUMBER_VISITS ~ AVERAGE_DISTANCE + NUMBER_NON_IMB +
 AGE_FIRST_VISIT + RACE_FIXED + ETHNICITY_FIXED + GENDER_FIXED, family =
 pospoisson(), data = PoissonData)
summary(PoissonTest)

#return exponentiated slope estimates for predictors
c(exp(coef(PoissonTest)))
```

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