

COMPARATIVE EFFECTIVENESS OF THE MODE OF DELIVERY FOR
PREVENTING DENTAL CARIES IN YOUNG CHILDREN

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Abstract

ASHLEY MERRILL KRANZ: Comparative Effectiveness of the Mode of Delivery for Preventing Dental Caries in Young Children
(Under the direction of R. Gary Rozier, DDS, MPH)

Background. Most state Medicaid programs reimburse primary care providers for providing preventive oral health services to young children in medical offices. Since 2000, North Carolina (NC) Medicaid has reimbursed these services through the Into the Mouths of Babies (IMB) program. To understand how the provider of oral health services may affect children's subsequent oral health-related outcomes, we compared children enrolled in NC Medicaid who received only IMB visits, only dentist visits, both IMB and dentist visits, and neither before 3 years of age.

Methods. Using a combination of NC administrative and public health surveillance data from 2000 to 2006, this study used regression methods to examine the following outcomes occurring after a child's third birthday: (1) time to a dentist visit; (2) receipt of caries-related treatment (CRT) and associated payments; (3) and the number of decayed, missing, and filled teeth (dmft) and proportion of untreated decayed teeth.

Results. Most children did not receive any preventive oral health services before age three; those who did were more likely to have IMB visits than dentist visits. Children who had only IMB visits had a longer time to a dentist visit following their third birthday, fewer CRT, and lower CRT payments than children who visited only dentists before age 3. Children who had multiple IMB or dentist visits had a similar number of dmft in

kindergarten, but children with only IMB visits had a higher proportion of untreated decayed teeth.

Conclusions. Although few children received preventive oral health services before age 3, those who did were more likely to have IMB visits than dentist visits. The similar dmft count of children with repeat IMB or dentist visits suggests that provider type does not influence the effectiveness of these services. However, children with only IMB visits may encounter challenges to obtaining follow-up treatment for tooth decay as these children experienced a longer time to a dentist visit following their third birthday and had more untreated decayed teeth. Results support the dissemination of this innovative model developed in NC, but also suggest enhancements are needed in linking medical and dental providers.

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Preface

This dissertation is organized in a non-traditional format, which includes three manuscripts. Chapter 1 provides an introduction to the dissertation and a description of the significance of the research. Chapter 2 provides background literature and describes the conceptual framework relevant to this dissertation. Chapter 3 describes the methodology used for each of the three studies in this dissertation. Chapters 4, 5 and 6 are the manuscripts for the three studies. These three chapters must stand alone as manuscripts to be submitted for publication and therefore have some redundancies with the earlier chapters. Chapter 7 presents a summary of the findings, policy implications, limitations of the studies, and directions for future research.

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List of Abbreviations

AHR	Adjusted hazard ratio
dmft	decayed, missing, or filled primary teeth
CRT	Caries-related treatment
ECC	Early childhood caries
IMB	Into the Mouths of Babes
IPTW	Inverse-probability-of-treatment-weights
NC	North Carolina
NCSO DC	North Carolina Surveillance of Dental Caries System
OLS	Ordinary Least Squares
PCP	Primary care provider

1. Introduction

1.1 Background

Early childhood caries (ECC), or tooth decay in young children, is prevalent in the United States, as over 25% of children aged 0 to 5 years old have the disease.¹ In addition to causing pain and decreased quality of life, ECC is costly to treat.² In 2006, Medicaid paid for 53% of children's hospital-based emergency department visits attributed to dental caries totaling \$14.33 million.³ Compared to children from higher-income families, children living in poverty are more likely to have dental caries, but less likely to receive treatment.¹ This difference is due in part to access to care, which is negatively affected by dental workforce shortages and dentists' low rate of participation in Medicaid.^{4,5}

Recognizing that young children make more visits to medical offices than dental offices, many state Medicaid programs now reimburse primary care providers (PCPs) for applying fluoride varnish in the medical office. Since 2000, the NC Into the Mouths of Babies (IMB) program has trained PCPs to provide oral health counseling to parents, conduct an open-mouth evaluation, and apply fluoride varnish to children younger than 3 years of age.⁶ Children suspected of having ECC or assessed to be at elevated risk are referred to dentists when they are available in the community. The IMB program, as well as similar programs in other states, has helped increase access to preventive dental services and improved the oral health of young children enrolled in Medicaid.⁷⁻⁹

Although the benefits of IMB visits are well-documented, less is known about what happens to the oral health of these children after three years of age, when they are no longer

eligible to receive preventive oral health services from PCPs. Compared to children not having IMB visits, children receiving at least four IMB visits received fewer treatments during ages 40-72 months and had a significantly lower monthly probability of having a dentist or hospital visit with caries-related treatment up to 6 years of age.^{8,10} While these findings suggest IMB visits may be associated with better oral health, these studies did not control for preventive services received from dentists or examine whether IMB visits promote oral health as well as visits to dentists, the conventional provider of these services. Some barriers to dental care for children may ease as they age because dentists are more willing to care for older children;¹¹ however, workforce shortages and dentists' low rate of participation in Medicaid likely remain as barriers to dental care when children age out of the IMB program.

1.2. Overall study purpose and approach

This dissertation includes three studies that compare the effectiveness of the mode of delivery for preventing dental caries in young children by medical and dental providers. Using administrative and oral health surveillance data, this dissertation compares modes of delivery by examining Medicaid-enrolled children's subsequent continuity of dental care, caries-related treatment, and dental caries experience in kindergarten. The first study examined continuity of dental care by estimating the time to a first dentist visit after their third birthday for children who had an IMB visit, dentist visit, or both before three years of age. The second study compared children who received preventive oral health services during only IMB visits, only dentist visits, both IMB and dentist visits, and neither before 3 years of age and examined the number of dental caries-related treatments received and payment for these treatments during 3 to 5 years of age. Finally, the third study compared

these four modes of delivery and examined caries experience and the proportion of untreated decayed teeth among kindergarten children enrolled in NC Medicaid.

1.3. Specific aims

All three studies use Medicaid claims to examine oral health-related outcomes occurring after a child's third birthday. Using Medicaid claims, the first two studies compare the effectiveness of the mode of delivery for preventing dental caries in young children by examining the time to a dentist visit (Study 1) and receipt of dental treatment and associated payments (Study 2). Study 3 uses a combination of NC Medicaid claims data and oral health surveillance data to compare clinical measures of dental caries experience. The aims for the three studies are as follows:

Study 1: To estimate the effect of the mode of delivery for preventive oral health services before 3 years of age on the time to a dentist visit after a child's third birthday. This retrospective cohort study included children who were enrolled in the NC Medicaid program before 1 year of age, enrolled for at least 12 months before their third birthday, and received oral health services at least once before age 3. The dependent variable was the time in months from a child's third birthday until his or her first dentist visit in an office-based setting. To compare children with only IMB visits to children with only dentist visits before age 3, we constructed a binary variable indicating the child received only IMB. To compare children with both IMB and dentist visits to children with only dentist visits before age 3, we constructed a binary variable indicating receipt of both IMB and dentist visits. Propensity scores with inverse-probability-of-treatment-weights, estimated by controlling for relevant child- and county-level variables, were used to address selection bias. Cox regression models were estimated using survival analysis.

Study 2: To estimate the effect of different modes of delivery on caries-related treatments and associated payments during ages 3 to 5 years. This retrospective cohort included children who were enrolled in the NC Medicaid program before 1 year of age, enrolled for at least 12 months before their third birthday, and enrolled for at least 8 months following their third birthday to allow time to observe the outcomes. The two dependent variables measured the number of dental CRT and total payments for CRT per year during ages 3 to 5 years. The key explanatory, mode of delivery for preventive oral health services before age three, was operationalized as a 4-category variable: dentists only, PCPs only, both dentists and PCPs, or neither. A zero-inflated negative binomial regression was used to estimate the total number of dental CRT received per year. Annual Medicaid payments for CRT at ages 3 to 5 years were estimated using a two-part regression model, with a logit model to estimate the likelihood of having any payments and an Ordinary Least Squares (OLS) regression model to estimate the expected payment for children having any CRT in a given year. All regression models controlled for relevant child- and county-level characteristics. Propensity score matching adjusted for selection bias.

Study 3: To estimate the effect of the mode of delivery for preventive oral health services before 3 years of age on the dental caries experience of kindergarten children. This retrospective cohort study included children who were enrolled in Medicaid before age one, still enrolled after their first birthday, and enrolled in kindergarten in NC during 2005-2006. We compared caries experience at five years of age for children who received preventive oral health services during IMB visits, dentist visits, both IMB and dentist visits, or neither before age 3. A zero-inflated negative binomial model was used to estimate caries experience, defined as the number of decayed, missing and filled primary teeth (dmft) and binomial

logistic regression was used to estimate the proportion of untreated decayed teeth (i.e., d/dmft). Regression models adjusted for relevant child- and county-level characteristics and used propensity scores with inverse-probability-of-treatment-weights.

1.4. Summary and significance

Widespread support exists for the integration of dentistry and medicine to promote young children's oral health, yet to date no study has directly compared the oral health-related outcomes of children utilizing modes of delivery for preventing dental caries in young children in medical and dental settings.¹²⁻¹⁵ As both the number of PCPs providing preventive oral health services and the number of children eligible for Medicaid increases, it becomes increasingly important to compare the effect of preventive oral health services delivered by PCPs to dentists, the conventional provider of these services.^{16,17} Furthermore, because children from low-income families are more likely to experience tooth decay and less likely to visit dentists than children from higher-income families,¹ Medicaid programs that reimburse services provided in medical offices can increase access to prevention for children living in poverty and thus may help to lessen oral health disparities. This dissertation compared the effectiveness of modes of delivery for preventing dental caries in young children in medical and dental settings by examining individual oral health-related outcomes including continuity of care, treatment utilization and associated payments, and dental disease. Results of the study can inform Medicaid policy on the reimbursement of preventive oral health services in the medical office and inform strategies to improve access to prevention for young children.

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2. Literature review

2.1. Background

Young children encounter difficulty accessing dental care, which contributes to increasing rates of early childhood caries (ECC) that disproportionately affect infants and toddlers living in poverty.¹ Recognizing that young children make more visits to medical offices than dental offices, many state Medicaid programs now reimburse primary care providers (PCPs) to deliver preventive oral health services.² Since 2000, North Carolina (NC) Medicaid's "Into the Mouths of Babes" (IMB) program has trained pediatric and family medicine PCPs to provide preventive oral health services to young children less than three years of age. Similar to preventive services received in a dental office for young children, IMB visits include oral health counseling for parents, application of fluoride varnish to prevent ECC, and an oral evaluation and risk assessment with referral to a dentist if needed.³

While the benefits of IMB visits have been well-documented, little is known about what happens to these children when they are no longer eligible to receive preventive oral health services from PCPs.⁴⁻⁶ Some barriers to dental care for children may ease as they age because dentists are more willing to care for older children;⁷ however, workforce shortages and dentists' low rate of participation in Medicaid remain as barriers to care when children age out of the IMB program. Despite enthusiasm for such interdisciplinary approaches, there is little evidence regarding its effectiveness compared directly with conventional dental care models.⁸⁻¹¹ This dissertation compared the oral health-related outcomes of children who

received preventive oral health services before age three during only IMB visits, only dentist visits, both IMB and dentist visits, and neither.

2.2. Dental disease is a major public health problem for young children

ECC, which is defined as the presence of tooth decay in children less than six years of age, is the most common chronic disease of childhood. ECC is five times more common than asthma and is increasing in prevalence.^{12,13} Among children 2-5 years old, ECC prevalence increased from 18% during 1988-1994 to 24% during 1999-2004.¹⁴ Despite this increase, treatment for ECC is underutilized, as 23.4% of young children suffer from untreated dental caries.¹⁵ Low-income children are twice as likely to experience ECC yet only half as likely to visit a dentist, suggesting that many young children with ECC who live in poverty do not receive necessary treatment.^{14,16} Because untreated ECC causes pain, which may limit participation in school activities and affect a child's ability to eat, speak, and sleep, ECC and its under treatment are important public health problems.¹⁷⁻²¹

In addition to causing pain and decreased quality of life, ECC is costly to treat.²¹ In 2006, Medicaid paid for 53% of children's hospital-based emergency department visits attributed to dental caries totaling \$14.33 million.²² A study conducted in Iowa found that although fewer than 5% of children on Medicaid received care for ECC in the hospital, these children consumed 25-45% of dental resources.²³ For children under 6 years of age enrolled in NC Medicaid, the average predicted payment for a dental caries-related treatment (CRT) episode ranges from \$334 for an office visit to \$3,051 for a hospital visit.²⁴

2.3. Preventive services can promote oral health during early childhood

Early interventions are particularly important for oral health promotion because having caries in primary teeth is a strong predictor of having caries in permanent teeth.²⁵

Because ECC can rapidly progress in young children, the early introduction of oral health promotion activities may help to avoid the consequences associated with it.²⁶ Early dentist visits are useful for establishing good oral health practices and evaluating caries-risk factors. A dentist visit by 12 months old is recommended by numerous professional organizations, including the American Academy of Pediatrics, American Academy of Pediatric Dentistry and American Dental Association.²⁷⁻²⁹ A dentist visit for a young child typically involves an oral exam and risk assessment, anticipatory guidance for parents about their child's oral health, and caries-prevention strategies such as use of topical fluoride.²⁹ An oral exam provides an opportunity to identify disease and develop a treatment plan based on ECC experience. A risk assessment is conducted to assess a child's likelihood of developing caries. Because caries is a disease caused by the interaction of multiple factors, dentists consider a child's exposure to variety of protective and harmful biological, behavioral and social characteristics.²⁷

Anticipatory guidance shared with parents is shaped by a dentist's assessment of risk. Following the medical model of anticipatory guidance, the dental model aims to provide developmentally appropriate information to parents about their child's oral health-related milestones.³⁰ Anticipatory guidance promotes good oral health behaviors early in the child's life by preparing parents for their child's future oral health needs.³¹⁻³⁴ The American Academy of Pediatrics recommends that providers educate parents about their child's oral hygiene and brushing habits, bottle use, and diet.⁸

An early dentist visit should also include a caries-prevention strategy, such as use of topical fluoride. Topical fluoride facilitates remineralization of the enamel and helps to reverse early signs of decay, which makes it effective at preventing caries.³⁵ Varnish is a safe

and convenient type of topical fluoride that provides an effective way to prevent dental caries in young children.^{36,37} Both the American Academy of Pediatric Dentistry and American Dental Association recommend young children at high risk of developing caries receive topical fluoride every three to six months.^{27,38}

In addition to the aforementioned activities, early dentist visits are important for establishing a dental home. The American Academy of Pediatric Dentistry defines a dental home as a “source of continuous, accessible, comprehensive, family-centered, coordinated, compassionate, and culturally effective oral health care delivered or directed by a professional dentist.”³⁹ Establishing a dental home is important for long-term oral health because it allows for the monitoring and treatment of potential problems.³⁹

2.4. Barriers to dentist visits persist for young Medicaid-enrolled children

Despite the expected benefits of preventive oral health services, early dentist visits may not be feasible for all young children, particularly for children from low-income families. The distribution and preferences of the dental workforce limit access to dentists for young children. According to the Institute of Medicine, over 49 million people live in federally recognized dental health provider shortage areas.⁴⁰ Nationally there are approximately 4.5 general dentists per 10,000 population, a number which has been steadily decreasing since 1994.⁴¹ Dental workforce shortages exist in NC, which has the 47th worst dentist-to-population ratio.⁴² Nationally, more than 35% of dentists are over age 55, thus the retirement of aging dentists in the coming years is expected to further decrease access.⁴¹ Even when general dentists are available, they may be reluctant to see young patients due to limited experience working with children. Although 87% of dental schools report teaching students that a first dental visit should occur by one year old, only 49% of schools provide

any clinical hands-on experience related to infant oral health.⁴³ Nationwide only 3% of dentists are pediatric dentists who receive special training on how to care for young children.⁴⁴ Similarly, NC has 3.31 pediatric dentists per 100,000 children.⁴⁵

Furthermore, Medicaid reimbursement rates affect access to dentists. Dentists routinely report low reimbursement rates as a reason for not participating in Medicaid.^{46,47} A recent study by Decker found that increasing Medicaid reimbursement to dentists was significantly associated with increased access to dental care for low-income children.⁴⁸ However, since 2000 few states have increased Medicaid dental payments and many states that have are considering reducing payments to control costs.^{48,49} Rate increases alone are unlikely to improve access adequately.¹¹ NC experienced only a marginal improvement in access to dental care after the state expanded eligibility and increased reimbursement.⁵⁰ Onerous administrative procedures and perceived difficulty dealing with patients may further discourage dentists' participation in Medicaid and negatively affect access to dental care for low-income children.^{51,52} Parents of children enrolled in Medicaid report difficulty finding providers, restrictive scheduling policies, and long wait times for appointments.⁵³ Moreover, the Medicaid reimbursement schedule may limit receipt of recommended preventive services. Although the American Academy of Pediatric Dentistry and the American Dental Association recommend young children at high risk of developing caries receive fluoride varnish every three to six months, many state Medicaid programs only reimburse preventive dentist visits every six months.^{27,38,54} Thus children may miss out on recommended care that is intended to prevent and interrupt the development of ECC.

In addition to structural barriers, parental characteristics may affect a child's access to a dentist. Miller and colleagues found that parents of children with severe caries treatment

needs were more likely to have lower oral health literacy than parents of children with mild to moderate treatment needs.⁵⁵ Furthermore, parents' beliefs about dental practices and primary teeth can affect utilization of dental care and oral health outcomes. Studies have found that parents who visit dentists are more likely to take their children to the dentist.^{56,57} However, lack of knowledge about oral health is common among low-income parents, particularly among parents of minority racial and ethnic backgrounds.⁵⁸ A study of low-income Hispanic mothers found that the mothers generally had limited knowledge of oral health promotion and their young children infrequently visited dentists.⁵⁸ In Detroit, Sohn and colleagues found an association between parental perception of their child's oral health and belief that poor oral health is acceptable and inevitable.⁵⁹ Although less than 30% of parents perceived their child's oral health as poor, nearly all of these parents (94%) reported fatalistic beliefs about oral health. A qualitative study of parents of young children from a racial-minority background, the majority of whom used public insurance, found that most parents placed little value on primary teeth often expressing the opinion that "they will 'just fall out anyway.'" ⁶⁰ Most parents in this study expressed a preference in visiting a pediatrician over a dentist for their child's first dental evaluation, suggesting greater familiarity and comfort with services delivered in the medical office and an opportunity to expand dental services in this setting.

2.5. To improve access to preventive oral health services, most Medicaid programs reimburse physicians for providing these services in the medical office

Recognizing that young children make more visits to medical offices than dental offices, most state Medicaid programs now reimburse pediatric PCPs to deliver preventive oral health services.² Since 2000, NC Medicaid's IMB program has trained pediatric and

family medicine PCPs to provide preventive oral health services to young children less than three years of age. Following an American Medical Association approved continuing medical education course, PCPs can provide preventive oral health services at a flat rate of about \$55 per child visit. Similar to preventive services provided in a dental office for young children, IMB visits include oral health counseling for parents, application of fluoride varnish to prevent ECC, and an oral evaluation and risk assessment.³ Children suspected of having ECC or assessed to be at elevated risk are referred to dentists when they are available in the community. IMB services may be provided at either well- or sick- child visits, although it is suggested they coincide with well-child visits occurring at 6, 9, 12, 15, 18, and 24 months of age. Consistent with recommendations from the American Academy of Pediatrics, children in NC are eligible to receive IMB services up to six times until 42 months of age, however during our study period children were only eligible until 36 months of age.⁸

The medical office provides a convenient setting to deliver preventive dental care to young children for several reasons. To begin, young children frequently visit the medical office because they are advised to have 11 well-child visits before their fourth birthday.⁶¹ Data from the Medical Expenditure Panel Survey revealed that 89% of children under two years old had an annual visit to the medical office, compared to only 1.5% who visited a dentist.⁸ Similarly, Yu and colleagues found that the proportion of children not making recommended visits was much lower for well-child visits than dentist visits.⁶²

In addition to being accessible to young children, PCPs are competent providers of oral health services. PCPs are able to identify ECC after receipt of training and they can integrate preventive dental care into the medical office.⁴ Among pediatric medical residents, receipt of an oral health education intervention was associated with increased knowledge and

more frequent participation in oral health activities.⁶³ One year after oral health training, most PCPs (70.3%) reported routinely providing dental services.⁶⁴ Fewer than half (42.1%) reported it was difficult to integrate dental procedures into practice and only 14.8% indicated that they lacked sufficient knowledge to provide dental services effectively.⁶⁴ Furthermore, parents report high satisfaction with these services.⁶⁵

The IMB program has helped to increase access to preventive oral health services for young children enrolled in Medicaid. Since 2000, the IMB program has supported over one million visits for preventive dental care in more than 425 health departments, physician practices and residency programs.⁶ Overall, the percent of Medicaid children younger than five years old obtaining oral health services in NC increased from 17% in 2002 to 59% in 2011.⁶⁶ In 2006, the rate of IMB visits was nearly four times the rate of dentist visits with fluoride; with 18-39% of children, depending on age, receiving at least one fluoride varnish application from a PCP.⁶

2.6. Gaps exist in the literature about the comparative effectiveness of delivering preventive oral health services during IMB visits compared to dentist visits

Although the benefits of IMB visits are well-documented, less is known about what happens to the oral health of these children after three years of age, when they are no longer eligible to receive preventive oral health services during IMB visits. Children who received 4 or more IMB visits compared to no IMB visits had a lower likelihood of receiving CRT in both hospital and office settings and a 17% reduction in CRT up to 6 years of age.^{5,24} Additionally, having 4 or more IMB visits was associated with lower Medicaid payments for hospital or dentist office treatments, suggesting fewer treatments within a treatment episode.²⁴ While these findings suggest IMB visits promote oral health, these studies did not

control for preventive services received from dentists or examine whether IMB visits promote oral health as well as visits to dentists, the conventional provider of these services.

IMB visits are intended to prevent and control the development of ECC until young children can more easily establish a dental home. Although not an explicit goal of the program before 2006, establishing a dental home is important for the long-term oral health of the child. Establishing a dental home is particularly important because IMB and a large percentage of these Medicaid programs limit benefits to children younger than 4 years of age, after which most of these children continue to be at high-risk of developing ECC and encounter barriers to dental care.² A study examining the IMB program during 2001-2002 found that only 3.4% of children had a dentist visit within six months of their first IMB visit.⁶⁷ Studies report that young children are more likely to have a dental visit if they received a referral from a physician.^{67,68} Nationally, fewer than half of young children aged 2 to 5 years old receive these types of referrals.^{68,69} Referral success is constrained by the availability of dentists willing to see young children enrolled in Medicaid.^{40,70} Early studies of the IMB program suggest that PCPs providing IMB services have low referral rates and tend to under-refer children with ECC.⁶⁷ Factors associated with referral include presence of ECC, PCP reported high confidence in screening for ECC, and availability of dentists.^{4,67,71} Although these studies of the IMB program provide information about the referral experience of children less than three years old, they do not address the experience children aging out of the IMB program.

For children receiving preventive oral health services during only IMB visits, the transition to a dentist at 3 years old has the potential to disrupt their continuity of dental care. Continuity of dental care, in this case defined as appropriate referral to specialists, is

achieved through successful referral from PCPs to dentists.⁷² This definition of continuity is related to the “health home” concept discussed by the American Association of Public Health Dentistry, which emphasizes the need for communication between patients and all of their healthcare providers in order to promote overall health.⁷³ Some barriers to dental care for children may ease as they age because dentists are more willing to care for older children;⁷ however, workforce shortages and dentists’ low rate of participation in Medicaid remain as barriers to dental care when children age out of the IMB program.

2.7. Conceptual framework

As illustrated in Figure 2.1, our framework for understanding utilization of dental care for young Medicaid enrollees posits that an individual’s decision to visit a dentist, or in this case a caregiver’s decision to take a child to the dentist, is influenced by four interrelated factors: history (past dental use), structure (sociodemographic characteristics and environmental factors), cognition (perception of need, perceived norms), and expectations (rewards and costs).⁷⁴ For study 1, we were primarily interested in understanding how past use of dental services (e.g., history) affects future visits to dentists. Although IMB visits are expected to facilitate subsequent access to dentists via parental counseling and referrals to dentists, children who received only IMB visits before age 3 may encounter barriers to dentists as they age. We hypothesized that past use of dental care, specifically visiting only dentists before age 3 would be associated with a shorter time to a dentist visit after a child’s third birthday. Because children who received both IMB and dentist visits before age 3 have a history of visiting dentists and may encounter fewer structural barriers to care (e.g., live in areas with more dentists), we hypothesized that these children would have a similar time to a dentist visit after their third birthday as children who visited only dentist visits before age 3.

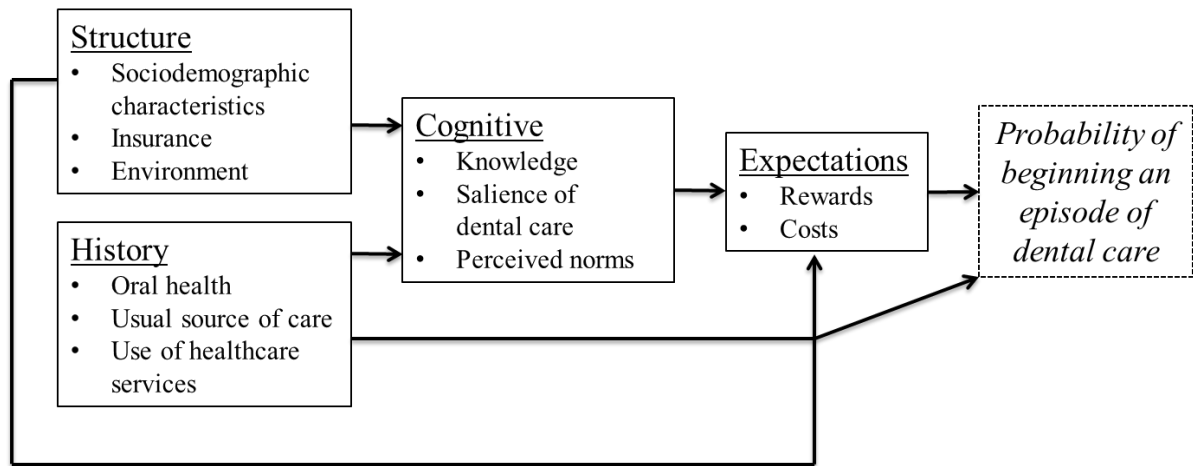
For studies 2 and 3, we examined how the provider of preventive oral health services before age 3 may affect subsequent dental treatment, payment for treatment, and dental caries experience. Children who received preventive oral health services during IMB or dentist visits before 3 years of age are expected to benefit from early screenings, parental counseling and applications of fluoride varnish.^{38,75} These actions correspond to the cognition factors in the conceptual framework and are expected to increase a parent's knowledge about their child health and encourage positive beliefs and attitudes about oral health promotion. Structural factors, such as the availability of dentists, may inhibit dentist visits for children who receive only IMB visits or no prevention. However, the preventive benefits extended to parents and children during IMB visits are expected to promote children's oral health status. Therefore, we hypothesized that children who have IMB or dentist visits before age 3 will have similar outcomes to each other, but fewer treatments, lower payments, and fewer dental caries than children who did not receive any prevention before age 3. Because children who have early dentist visits may do so to obtain treatment or because they are at increased risk of ECC, we also considered that our results may reflect this unobserved risk status and indicate that early dentist visits are associated with more treatment. Furthermore, because the IMB program instructs PCPs to refer children with existing dental disease to dentists, and having decay at an early age is a strong predictor of subsequent decay,⁷⁶ we hypothesized that children who received both IMB and dentist visits before 3 years of age will have more treatment, higher payments, and more dental caries than children who had only IMB or only dentist visits before age 3.

2.8. New contributions

To date, research examining preventive oral health services delivered by medical and

dental providers has been conducted in silos, with no studies directly comparing the outcomes associated with these modes of delivery. No studies have compared the oral-health related outcomes of children who had only IMB visits to children who had only dentist visits before three years of age. Furthermore, studies evaluating the IMB program have not controlled for dentist visits when reporting the effect of IMB utilization, which is an important predictor of oral health status and caries-related treatments.^{5,67} Nationally, as both the number of PCPs providing preventive oral health services and the number of children eligible for Medicaid increases, it becomes increasingly important to compare the effect of preventive oral health services delivered by PCPs to dentists.⁷⁷ This dissertation extends previous evaluations of the IMB program by comparing the oral health-related outcomes of children who received only IMB visits, only dentist visits, both IMB and dentist visits, and neither before 3 years of age.

Figure 2.1. Conceptual framework



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3. Methods

3.1. Overview of methods

This dissertation is comprised of three manuscripts contained in chapters 4, 5 and 6 which are referred to as study 1, study 2, and study 3, respectively. This chapter provides an overview of the methods used in each study. Because the manuscripts must stand alone, there are redundancies in each manuscript and this chapter. Study 1 and study 2 primarily used data from NC Medicaid claims during years 2000-2006. Study 3 used Medicaid claims that were previously linked to oral health surveillance data. All studies also used additional publically available data to construct relevant county-level variables.

3.2. Research design

This dissertation compared the effectiveness of modes of delivery for preventing dental caries in young children in medical and dental settings by examining the time to a dentist visit (Study 1), receipt of dental treatment and associated payments (Study 2), and dental caries experience in kindergarten (Study 3). Study 1 used a retrospective cohort design to compare the time to a dentist visit for children who had only IMB visits, only dentist visits, or both IMB and dentist visits before age 3. Studies 1 and 2 used a retrospective cohort design to compare children who received preventive oral health services before age 3 during only IMB visits, only dentist visits, both, or neither and examined receipt of caries-related treatment, payment, and dental caries experience.

3.3. Data sources

The analytical samples for studies 1 and 2 are derived entirely from NC Medicaid

enrollment and claims files. Study 3 used NC Medicaid files along with oral health surveillance data to examine a cohort of children entering kindergarten during the 2005-06 school year. All studies included additional county level data. The variables used for each study are listed in Table 3.1.

3.3.1. Medicaid claims and enrollment files

Obtained from the NC Division of Medical Assistance, these files provide information about the dental and medical Medicaid claims of children enrolled from 2000-2006. These files were originally obtained in order to evaluate the effectiveness of the direct referral component of the IMB program and later used to examine the effect of an early preventive dentist visit on oral health outcomes.^{1,2} Enrollment files provide information about demographic characteristics and Medicaid enrollment (length of time enrolled, reason child is eligible for Medicaid, etc.). Claims files provide information about the type of procedure received, the amount paid for the procedure, where the procedure occurred, and what type of provider submitted the claim (e.g., dentist or physician). Pharmacy or drug claims were not obtained.

3.3.2. NC Surveillance of Dental Caries System (NCSO DC)

The NC Oral Health Section conducts annual oral health assessments of all children in kindergarten and fifth grade. NC began conducting assessments during the 1996-97 school year and is the only state to annually collect this type of surveillance data. Each year, public health dental hygienists conduct standardized open mouth screenings, which provide information about dental disease levels, treatment needs and presence of sealants.^{3,4} The Oral Health Section uses this data to identify communities with the greatest need for dental services and monitor trends in oral health. The NCSO DC provides a count of decayed,

missing (molars only), and filled primary teeth for each child. NCSO DC also collects demographic information, such as the child's name, date of birth, sex, race, gender, county of residence, school name, and classroom identification number. Study 3 used data collected during the 2005-06 school-year, which includes information on 92,127 children, 82% of the state's public school kindergarten enrollment, from 98 of 100 counties.⁵ The NCSO DC data and NC Medicaid files were previously linked by Beil and colleagues using Link King software, which uses probabilistic and deterministic methods, based on the child's name, date of birth, gender, race, and county of residence.⁶ Children were included in the Medicaid sample if they were enrolled in Medicaid before their first birthday, still enrolled after one year old, and subsequently identified in the NCSO DC data.

3.3.3. County-level data sources

Several publicly available data sources were used to obtain measures of county-level characteristics. The North Carolina Health Professionals Data System, maintained by the Cecil G. Sheps Center for Health Services Research at the University of North Carolina at Chapel Hill, provided county-level estimates of the number of dentists and the number of pediatricians and family practice physicians per 10,000 population.⁷ We obtained annual measures of the number of Medicaid eligible children under 21 years old per county from the NC Division of Medical Assistance.⁸ A measure of the proportion of each county's population with access to fluoridated public drinking water was previously obtained from the NC Oral Health Section.⁹ We obtained rural-urban continuum codes from the Economic Research Service in the US department of Agriculture. This nine category coding scheme provided a sensitive measure that enabled us to distinguish between metropolitan and nonmetropolitan counties.¹⁰

3.4. Overview of data analysis

3.4.1. Study 1: Effect of the mode of delivery for preventive oral health services before 3 years of age on the time to a dentist visit after a child's third birthday

For study 1, we hypothesized that past use of dental care, specifically visiting only dentists before age 3 would be associated with a shorter time to a dentist visit after a child's third birthday. Because children who received both IMB and dentist visits before age 3 have a history of visiting dentists and may encounter fewer structural barriers, we hypothesized that these children would have a similar time to a dentist visit after their third birthday as children who visited only dentists before age 3.

The primary outcome was the time in months from a child's third birthday until his or her first dentist visit in an office-based setting, which was operationalized as any paid claim filed by a dentist up to three years following the child's third birthday. Observations were censored when the child had an office-based dentist claim, was no longer enrolled in Medicaid, or turned 6 years old. To compare children with only IMB visits and children with only dentist visits before age 3, we constructed a binary explanatory variable indicating the child received only IMB visits before 3 years of age. Visits to a dentist office for any reason were identified as any paid claim filed by a dentist before a child's third birthday. To compare children with both IMB and dentist visits and children with only dentist visits before age 3, we constructed a binary variable indicating receipt of both IMB and dentist visits before 3 years of age.

To address selection bias that could arise because of observed systematic differences between children, we utilized propensity scores with inverse-probability-of-treatment-weights (IPTW). Using logistic regression, we controlled for the covariates identified in

Table 3.1 and included squared terms of continuous variables and estimated two propensity scores by (1) predicting the likelihood of having only IMB visits compared to only dentist visits before age 3 (excluding children with both IMB and dentist visits) and (2) predicting the likelihood of having both IMB and dentist visits compared to only dentist visits before age 3 (excluding children with only IMB visits). We compared the time to a dentist visit after a child's third birthday (IMB only *versus* dentist only and both IMB and dentist *versus* dentist only) by constructing IPTW-adjusted Kaplan-Meier (KM) curves (calculated 1-KM) and tested for differences by using IPTW-adjusted Cox proportional hazard models, including IMB only or both IMB and dentist visits as the only covariate.¹¹ Huber-White empirical standard errors adjusted for intra-group correlation due to clustering of children within counties. Additionally, we conducted a sensitivity analysis to explore whether the number of dentists per county altered the effect of IMB visits on the time to a dentist visit by estimating a Cox model with an interaction term between a continuous measure of the number of dentists and the IMB indicator variable. Adjusted hazard ratios were compared using Wald tests and 95% confidence intervals.

3.4.2. Study 2: Effect of different modes of delivery on caries-related treatments and associated payments during ages 3 to 5 years

Study 2 tested the hypothesis that children who received preventive oral health services during IMB or dentist visits before 3 years of age have a similar number of dental CRT and payments during ages 3-5 years as each other, but fewer CRT and lower payments than children who did not receive any prevention before age 3. We examined two outcomes: dental CRT and total payments for treatment. The total number of CRT a child received per year for ages 3, 4, and 5 years old were identified using Current Dental Terminology codes

beginning with D2, D3, D4, D5, D6, D7, D8, and D9, which include amalgam restorations, composite restorations, extractions, crowns, and nerve-related treatments (pulpotomies/pulpectomies). Payment for CRT was identified in Medicaid claims and summed to estimate annual treatment payments for ages 3, 4, and 5 years. To account for inflation over the study period, treatment payments were adjusted to constant 2006 U.S. dollars using the Gross Domestic Product price index.¹² The main explanatory variable was operationalized as a 4-category variable indicating the delivery setting and provider for preventive oral health services before age three: IMB visits only, dentist visits only (*reference group*), both dentist and IMB visits, and neither.

We were concerned about selection bias that may arise due to differences between children with and without dentist visits because it is unknown if these visits are for existing disease or demand for preventive services. To address this possible selection bias, we utilized propensity score matching. Propensity score matching methods typically used for a two-group treatment variable were adapted for this analysis of a four-group treatment variable (type of provider).¹³ Because we have four groups with four different sample sizes, we used a three-stage matching strategy to obtain an analytical sample with a similar distribution of covariates across all groups. Propensity scores were estimated using logistic regression and controlled for the covariates in Table 3.1, including squared terms of continuous variables. First, we estimated the likelihood of having an IMB visit before age 3 for children who received only IMB visits or no preventive oral health services before age 3 because these two groups have the largest number of observations. We excluded from matching children having propensity score values beyond the region of common support (i.e., having values outside the range of the other group)¹³. For this and all subsequent matches, we used the user written

Stata program PSMATCH2 and performed single nearest neighbor matching using a caliper equal to 0.20 of the standard deviation of the propensity score. Second, we estimated the likelihood of having a dentist visit only before age 3 for children who received only dentist visits or both dentist and IMB visits before age 3 because these two groups have the fewest observations. We excluded children beyond the common support region and performed single nearest neighbor matching. Using only the matched observations stemming from these two regression models, we then estimated the likelihood of having a dentist visit (with or without IMB visits) before age 3. We excluded children beyond the common support region and performed single nearest neighbor matching. To evaluate covariate balance in the final matched sample across our four-group treatment variable, we compared the distribution of propensity scores from the final regression model in the full and matched samples. Additionally, we examined changes in absolute standardized differences of variables across treatment groups in the full and matched samples.¹⁴

A zero-inflated negative binomial regression was used to estimate the total number of dental CRT received per year per child for ages 3, 4, and 5 years old, a model appropriate for a count dependent variable with excess zeros.¹⁵ This model included an offset term equal to the logged number of months the child was enrolled in Medicaid at each age. Annual Medicaid payments for CRT at ages 3 to 5 years were estimated using a two-part regression model, which is appropriate for a continuous dependent variable with excess zeros.¹⁶ First, a logistic regression model was used to estimate the likelihood of having any treatment payments during a year. Second, an Ordinary Least Squares (OLS) regression model was used to estimate the expected treatment payments during each age for children having any CRT in a given year. These results were transformed using a smearing estimator for

heteroskedastic and normal errors. Regression models controlled for the covariates described in Table 3.1. Standard errors were clustered at the child-level to adjust for repeat observations over time. Estimates from the logistic and OLS regression models were combined using 200 bootstrap replications to obtain an estimate of the expected annual payments for children aged 3 to 5 years receiving preventive oral health services during IMB visits, dentist visits, both IMB and dentist visits, and neither. Differences in mean expected outcomes were examined using Wald tests and 95% confidence intervals.

3.4.4. Study 3: Effect of the mode of delivery for preventive oral health services before 3 years of age on the dental caries experience of kindergarten children

For study 3, we hypothesized that children who received preventive oral health services before age 3 during IMB visits and dentist visits will have a similar number of decayed, missing and filled primary teeth (dmft) and proportion of untreated decayed teeth as each other, but fewer dmft and a lower proportion of untreated decayed teeth than children who did not receive prevention before age 3. To understand the effect of the mode of delivery for preventive oral health services before 3 years of age on dental caries experience, we examined two outcomes. First, caries experience was measured, based on visual inspection, as the total number of dmft of children enrolled in kindergarten. Second, to better understand a child's access to dental treatment, we examined the proportion of a child's caries experience that was untreated at the examination, defined as the number of decayed teeth divided by the total dmft score among those with $dmft > 0$. As described in study 2, the main explanatory variable was operationalized as a 4-category variable indicating the delivery setting and provider for preventive oral health services before age three: IMB visits only, dentist visits only (*reference group*), both dentist and IMB visits, and neither.

Propensity scores with IPTW were used to address selection bias that could arise because of systematic differences between children with and without dentist visits. We were concerned about selection bias associated with visits to dentists because it is unknown if these visits are due to existing disease or demand for preventive services. Propensity scores were estimated using logistic regression, controlling for the covariates identified in Table 3.1 and squared terms of continuous variables, and predicted the likelihood of having a dentist visit with preventive services before age three. To ensure appropriate comparison groups, we excluded children without dentist visits with a propensity score higher than the maximum or lower than the minimum propensity score of children with dentist visits. We calculated standardized weights for each child.¹⁷

A zero-inflated negative binomial regression model was used to compare the overall mean number of dmft at five years old for children according to use of the four modes of delivery for preventive oral health services. A binomial logistic regression for d/dmft (where d/dmft is the number of “events”/number of “trials”) was used to estimate the mean proportion of decayed teeth untreated for children with some dmft utilizing each mode of delivery.¹⁸ Huber-White empirical standard errors adjusted for intra-group correlation due to clustering of children within counties. Regression models controlled for the covariates in Table 3.1. Predicted outcomes for each mode of delivery were estimated using the full sample, with 95% confidence intervals generated using 1,000 bootstrap replications. Differences in outcomes were examined using Wald tests and 95% confidence intervals.

Table 3.1. Description of variables

Variable description	Type	Study aim	Source [‡]
<i>Dependent variables</i>			
Time to dentist visit during ages 36-71 months	continuous	1	1
Number of caries-related treatments per year	count	2	1
Payments for caries-related treatment per year	continuous	2	1
Index of decayed, missing, and filled primary teeth	count	3	2
Proportion of decay that is untreated	proportion	3	2
<i>Explanatory variables</i>			
Mode of delivery for preventing dental caries before 3 years of age			
Indicator of IMB visits only (reference group: dentist visit only)	binary	1	1
Indicator of both IMB and dentist visits (reference group: dentist visit only)	binary	1	1
IMB visits only, dentist visits only (reference group), both IMB and dentist visits, or neither	categorical	2,3	1
Months enrolled in Medicaid after 3 years of age	continuous	1,2,3, PS	1
Year child turned 3 years old	categorical	1, 2, PS	1
Age in years	categorical	2	1
Dental visit <6 months before 3 years of age	binary	1	1
Indicator that oral health services were received in a Federally Qualified Health Center, health department, or rural health clinic before 3 years of age	binary	1,2,3, PS	1
Indicator that any caries-related treatment was received before 3 years of age	binary	3	1
Number of well-child visits before 3 years of age	continuous	1,2,3, PS	1
Indicator that child has special health care needs	binary	1,2,3, PS	1
Child's gender (reference group: female)	binary	1,2,3,PS	1
Child's race and ethnicity			
White	binary	1,2,3, PS	1
Black	binary	1,2,3, PS	1
Hispanic	binary	1,2,3, PS	1
Level of urbanization of county	categorical	1,2,3,PS	3
Medicaid eligibles under 21 years of age per 10,000 county population	continuous	1,2,3,PS	3
Dentists per 10,000 county population	continuous	1,2,3,PS	3
Pediatricians and family practice physicians per 10,000 county population	continuous	1,2,3PS	3
Proportion of county population with access to fluoridated drinking water	categorical	2,3	3

[‡]Data sources: 1. NC Medicaid claims data, 2. NCSO DC, 3. Other

PCP, primary care provider; PS, propensity score

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4. Effect of the mode of delivery for preventive oral health services before 3 years of age on the time to a dentist visit after a child's third birthday

4.1. Overview

To understand continuity of dental care for children receiving oral health services in medical offices via the Into the Mouths of Babies (IMB) program, we examined the time to a dentist visit after a child's third birthday. We used North Carolina Medicaid claims from 2000-2006 for 95,578 children enrolled in Medicaid before 1 year of age who received oral health services before age 3. This retrospective cohort study compared having only dentist visits before age 3 to (1) only IMB visits and to (2) both IMB and dentist visits and examined the time to a dentist visit following a child's third birthday. Propensity scores with inverse-probability-of-treatment-weights were used to address selection bias. Regression models were estimated using survival analysis. Children with only IMB visits compared to only dentist visits before age 3 had lower rates of dentist visits after their third birthday (adjusted hazard ratio [AHR]=0.41; 95% CI=0.39 to 0.43). No difference was observed for children having both IMB and dentist visits and only dentist visits (AHR=0.99; 95% CI, 0.96 to 1.03). Barriers to dental care remain as children age, hindering continuity of care for children receiving oral health services in medical offices.

4.2. Introduction

Dentist visits for young children provide an opportunity to establish good oral health practices, evaluate factors associated with caries-risk, and monitor and treat potential

problems. Early interventions are important for oral health promotion because early childhood caries (ECC) can progress rapidly in young children. Oral health promotion activities, introduced at an early age, may help to avoid the consequences associated with ECC, which include pain, decreased quality of life, and treatment costs.¹ Dentist visits are particularly important for Medicaid-enrolled children, as children living in poverty are more likely to experience tooth decay than children from higher-income families.² Despite recommendations that children visit a dentist by their first birthday, few young children enrolled in Medicaid visit dentists.³⁻⁵ During 2007, only four states (Iowa, North Carolina (NC), Texas, and Washington) had 20% or more Medicaid-enrolled children younger than 3 years of age visit dentists.⁶ Young Medicaid-enrolled children encounter barriers to dentists due to workforce shortages and dentists' reluctance to see young children and accept Medicaid.^{7,8}

To address these barriers and improve access to preventive oral health services for young Medicaid-enrollees, since 2000 the NC Medicaid Into the Mouths of Babies (IMB) program has trained primary care providers (PCP) to deliver preventive oral health services to children younger than 3 years of age. IMB visits include oral health counseling for parents, an open-mouth evaluation, and application of fluoride varnish.⁹ Children suspected to have ECC or otherwise are at elevated risk are referred to dentists when they are available in the community. Currently, more than 40 state Medicaid programs have adopted policies to reimburse pediatric and family medicine PCPs for providing fluoride varnish in medical offices.¹⁰ The IMB program, as well as similar programs in other states, has helped increase access to preventive dental services and improved the oral health of young children enrolled in Medicaid.¹¹⁻¹⁴

IMB visits are intended to prevent and control the development of ECC until young children can more easily establish a dental home, where care is comprehensive and continuously accessible.¹⁵ Establishing a dental home is particularly important because a large percentage of these Medicaid programs limit benefits to children younger than 4 years of age, after which most of these children continue to be at high-risk of developing ECC and encounter barriers to dental care.¹⁰ This timeframe for IMB services is intended to coincide with the early childhood periodicity schedule that recommends well-child visits occur at 6, 9, 12, 15, 18, and 24 months of age.¹⁶ Reimbursement for IMB services ends after a child's third birthday because well-child visits in the medical office become less frequent and more dentists are willing to accept older children as patients.¹⁷

For children receiving IMB services, the transition to a dentist at 3 years old has the potential to disrupt their continuity of dental care. Continuity of dental care, in this case defined as appropriate referral to specialists, is achieved through successful referral from PCPs to dentists.¹⁸ Studies report that young children are more likely to have a dental visit if they received a referral from a physician.^{19,20} Nationally, fewer than half of young children aged 2 to 5 years old receive these types of referrals.^{19,21} Referral success is constrained by availability of dentists willing to see young children enrolled in Medicaid.^{7,8} Early studies of the IMB program suggest that PCPs providing IMB services have low referral rates and tend to under-refer children with ECC.^{20,22} Factors associated with referral include presence of ECC, PCP reported confidence in screening for ECC, and availability of dentists.^{20,23}

Few studies have examined dentist visits occurring after a child is no longer eligible to receive oral health services in the medical office. Compared to children not having IMB visits, children receiving at least four IMB visits received fewer treatments during ages 40-72

months and had a significantly lower monthly probability of having a dentist or hospital visit with caries-related treatment up to 6 years of age.^{12,13} However, no study has compared utilization of dental care for children with IMB visits to children visiting dentists, the conventional provider of oral health services.

This study examined continuity of dental care for Medicaid-enrolled children aging out of the IMB program. We compared the time to a dentist visit following a child's third birthday for children who had only IMB visits to children who had only dentist visits before 3 years of age. Additionally, to examine continuity of dental care for children living in counties with an adequate dental workforce that allows for successful referral to dentists, we compared the time to a dentist visit for children who had both IMB and dentist visits to children who had only dentist visits before 3 years of age.

4.3. Methods

4.3.1. Data and study population

We obtained Medicaid enrollment and claims files for 400,956 children enrolled during 2000 to 2006 from the NC Division of Medical Assistance. Because we were interested in examining continuity of dental care over time, we limited our sample to children who received oral health services at least once before age 3 during an IMB visit or dentist visit in an office-based setting (n=176,970). We included children who were enrolled in the NC Medicaid program before 1 year of age and enrolled for at least 12 months before their third birthday. We excluded children not still enrolled in Medicaid after their third birthday because we were unable to identify dentist visits obtained after their third birthday. The study was approved by an Institutional Review Board at the lead author's university.

4.3.2. Framework

Our framework for understanding utilization of dental care for young Medicaid enrollees posits that an individual's decision to visit a dentist, or in this case a caregiver's decision to take a child to the dentist, is influenced by four interrelated factors: history (past dental use), structure (sociodemographic characteristics and environmental factors), cognition (perception of need, perceived norms), and expectations (rewards and costs).²⁴ To examine continuity of dental care, we were primarily interested in understanding how past use of dental services (e.g., history) affects future visits to dentists. Although IMB visits are expected to facilitate subsequent access to dentists via parental counseling and referrals to dentists, children who received only IMB visits before age 3 may encounter barriers to dentists as they age. We hypothesized that past use of dental care, specifically visiting only dentists before age 3 would be associated with a shorter time to a dentist visit after a child's third birthday. Because children who received both IMB and dentist visits before age 3 have a history of visiting dentists and may encounter fewer structural barriers to care (e.g., live in areas with more dentists), we hypothesized that these children would have a similar time to a dentist visit after their third birthday as children who visited only dentist visits before age 3.

4.3.3. Measures

The primary outcome was the time in months from a child's third birthday until his or her first dentist visit in an office-based setting, which was operationalized as any paid claim filed by a dentist up to three years following the child's third birthday. We use this time period because during the study period Medicaid reimbursed PCPs for up to six IMB visits before age 3; and children 6 years and older may receive help obtaining oral health services within their schools. Observations were censored when the child had an office-based dentist

claim, was no longer enrolled in Medicaid, or turned 6 years old.

To compare children with only IMB visits and children with only dentist visits before age 3, we constructed a binary variable indicating the child received only IMB visits before 3 years of age. IMB visits were identified with paid claims filed by physicians for preventive oral health services. Current Dental Terminology codes used to identify IMB visits are provided in Table 4.1. Visits to a dentist office for any reason were identified as any paid claim filed by a dentist before a child's third birthday. To compare children with both IMB and dentist visits and children with only dentist visits before age 3, we used this same strategy to construct a binary variable indicating receipt of both IMB and dentist visits before 3 years of age.

Baseline characteristics, derived mostly from Medicaid files, were included as explanatory variables. Variables identifying past use of healthcare services included: number of well-child visits, months enrolled in Medicaid, indicators of special health care needs, whether the child visited a dentist less than 6 months prior to his or her third birthday, and whether any oral health services were received in a Federally Qualified Health Center (FQHC), health department, or rural health clinic. We controlled for sociodemographic variables, including: sex, race (white, black, other (reference group)) and Hispanic ethnicity. Characteristics of the child's environment that are expected to influence the time to a dentist visit include: the county level number of dentists and pediatricians and family practice physicians per 10,000 population²⁵ and the proportion of the county population aged 0-18 years enrolled in Medicaid²⁶, year of child's third birthday, and indicators of the county's level of urbanization and proximity to metro areas.²⁷

4.3.4. Propensity score estimation

To address selection bias that could arise because of observed systematic differences between children, we utilized propensity scores with inverse-probability-of-treatment-weights (IPTW). We were particularly concerned because it is unknown if dentist visits are due to existing disease or demand for preventive services. Using logistic regression, we estimated two propensity scores by (1) predicting the likelihood of having only IMB visits compared to only dentist visits before age 3 (excluding children with both IMB and dentist visits) and (2) predicting the likelihood of having both IMB and dentist visits compared to only dentist visits before age 3 (excluding children with only IMB visits). We controlled for the aforementioned covariates, including squared terms of continuous variables. Standardized weights were calculated for each child, an approach that assigns greater weight to children who visited dentists before age 3 but appear more similar based on observed characteristics to children who did not visit dentists before age 3 and vice-versa.²⁸ Adjustment using IPTW produces an estimate of the average treatment effect.²⁹ Covariate balance was evaluated by examining the distribution of propensity scores and standardized differences of variables before and after weighting.³⁰

4.3.5. Analytic approach

Descriptive statistics were calculated for variables based on whether oral health services were provided during IMB visits, dentist visits, or both before 3 years of age. Using chi-squared tests to compare proportions and t-tests to compare means, we examined differences in variables for children who received only dentist visits before age 3 compared to only IMB visits and compared to both IMB and dentist visits. We compared the time to a dentist visit after a child's third birthday (IMB only *versus* dentist only and both IMB and

dentist *versus* dentist only) by constructing IPTW-adjusted Kaplan-Meier (KM) curves (calculated 1-KM) and tested for differences by using IPTW-adjusted Cox proportional hazard models, including IMB only or both IMB and dentist visits as the only covariate.³¹ Huber-White empirical standard errors adjusted for intra-group correlation due to clustering of children within counties. Additionally, we conducted a sensitivity analysis to explore whether the number of dentists per county altered the effect of IMB visits on the time to a dentist visit by estimating a Cox model with an interaction term between a continuous measure of the number of dentists and the IMB indicator variable. Adjusted hazard ratios (AHR) were compared using Wald tests and 95% confidence intervals (CI). All analyses were performed in Stata/IC 12 (Statacorp, College Station, TX) using a 0.05 significance level.

4.4. Results

Of the 95,578 NC Medicaid-enrolled children included in this analysis, 63% received only IMB visits (n=60,124), 23% received only dentist visits (n=22,061), and 14% received both IMB and dentist visits before their third birthday (n=13,393) (Table 4.2). Separate analyses were conducted to compare children having only IMB visits and only dentist visits before age 3 (n=82,185) and children having both IMB and dentist visits and only dentist visits before age 3 (n=35,454). Compared to children with dentist visits before age 3, children with only IMB visits had more well-child visits, were more likely to receive oral health services in an FQHC, and lived in counties with more Medicaid eligible children and fewer dentists. On average, children with both IMB and dentist visits before age 3 had more well-child visits and were more likely to receive oral health services in an FQHC than children who visited only dentists before age 3. Dentist visits occurring between 3 and 6

years of age were more common among children who had only dentist visits (70%) or both IMB and dentist visits before age 3 (66%) than children who had only IMB visits (44%).

4.4.1. Propensity scores

Following IPTW adjustment, the distribution of propensity scores was more similar for children having only IMB visits compared to only dentist visits before age 3 and for children having both IMB and dentist visits compared to only dentist visits before age 3 (Figures 4.1A and 4.1B, respectively). Adjustment by IPTW improved balance of covariates as evidenced by reductions in absolute standardized differences for covariates (Figure 4.2). Results obtained from the unadjusted and IPTW adjusted sample were similar in direction and significance. All results presented below are for the IPTW adjusted sample.

4.4.2 Only IMB visits compared to only dentist visits before age 3

Kaplan–Meier curves provide an estimate of the cumulative probability of having a dentist visit after a child’s third birthday. Children who had only IMB visits before age 3 had a 29% probability of a dentist visit within 12 months after their third birthday, which increased to 70% within 36 months after their third birthday (Figure 4.3A). Children who visited only dentists before age 3 had a 62% probability of a dentist visit within 12 months after their third birthday, which increased to 90% within 36 months after their third birthday. Having only IMB visits compared to only dentist visits was associated with a significantly lower hazard of a dentist visit after a child’s third birthday (AHR=0.41; 95% CI, 0.39 to 0.43) (Table 4.3).

4.4.3. Both IMB and dentist visits compared to only dentist visits before age 3

The time to a dentist visit after a child’s third birthday was similar for children who had both IMB and dentist visits and children who had only dentist visits before age 3 (Figure

4.3B). For these children, the probability of a dentist visit within 12 months after their third birthday was 63% and increased to more than 88% within 36 months after their third birthday. Rates of dentist visits after children's third birthday were not significantly different for children who received both IMB and dentist visits or only dentist visits before age 3 (AHR=0.99; 95% CI, 0.96 to 1.03) (Table 4.3).

4.4.4. Sensitivity analysis

Increasing the number of dentists per county slightly increased the hazard of a dentist visit for children having only IMB visits compared to only dentist visits before age 3 (Table 4.3). The number of dentists in a county did not alter the effect of having both IMB and dentist visits on the time to a dentist visit.

4.5. Discussion

Preventive oral health services provided by PCPs in the medical office help to improve young children's access to care. Because most state Medicaid programs limit benefits to children younger than 4 years of age, we wanted to examine children's continuity of dental care as they age.¹⁰ Using NC's long-implemented IMB program, we examined the time to a dentist visit after a child's third birthday.

Before age 3, more children received oral health services during IMB visits (n=73,517) than during dentist visits (n=35,454). Consistent with national estimates, we found that prevalence of dentist visits increased with age, as 60% of children had a dentist visit between 3 to 6 years of age.⁶ Children having dentist visits before age 3 had at least an 89% probability of having a dentist visit between 3 to 6 years of age. Continuity of dental care was more likely to be achieved by children having both IMB and dentist visits than children with only IMB visits before age 3. The probability of dentist visit during ages 3 to 6

years ranged from 70% for children with only IMB visits to 89% for children with both IMB and dentist visits before age 3.

We hypothesize that the difference observed in the time to a dentist visit for children receiving only IMB visits compared to dentist visits before age 3 may be due to: need, referral practices in medical offices, and barriers to dental care. First, children visiting dentists before 3 years of age may do so because they have ECC or are at high risk of developing it. Because we lack clinical measures of oral health status, we cannot assess either appropriateness of care received by children who had a dentist visit or unmet needs of children not visiting dentists. However, among children who visited dentists before age 3, 35% received caries-related treatment prior to their third birthday compared to less than 1% of children who received only IMB visits. Because past dental caries experience is a strong predictor of future dental disease, we would expect high-risk children to have a higher rate of dentist visits.³²

Second, medical offices providing IMB services may need to be more attentive to referrals, particularly when children get near the end of their eligibility for IMB services. Referrals from physicians increase young children's likelihood of having a dental visit.^{19,20,33} However, few children obtaining IMB services receive referrals, and fewer than half of parents received help scheduling the dentist visit.^{20,34} Among children having IMB visits, 22% also visited a dentist before age 3. This subgroup of children receiving IMB services was more likely to be able to successfully transition to a dental home following the end of their eligibility for the IMB program. Although our administrative data cannot identify which children received referrals, 99% of these children had an IMB visit before their first dentist visit. Compared to the other children in this study, on average children who received both

IMB and dentist visits were more likely to receive oral health services in a public clinic and had the most well-child visits before age 3.

Finally, a third possible explanation for difference in the time to a dentist visit after age 3 may be that barriers to dentist visits endure overtime and are unlikely to change as a child ages. Having a prior dentist visit was a strong predictor of subsequent visits, suggesting that children who initially overcame barriers to dentist visits continued to do so over time. Compared to children making only IMB visits, children visiting dentists before age 3 lived in more urban counties with more dentists. A prior study reported that IMB services are more likely to be provided in rural counties where dental workforce shortages are most pronounced.¹¹ We found that having more dentists in a county was associated with a slightly higher hazard of a dentist visit for children having only IMB visits. Additional barriers to care reported by parents of Medicaid-enrolled children include difficulty finding willing providers, restrictive scheduling policies, and long wait times for appointments.^{35,36} Young children are likely to face increasing difficulty in accessing dentists as more children become eligible for dental services through enrollment in Medicaid enabled by the Affordable Care Act.³⁷

To promote continuity of dental care for children as they age and to increase the time available for transition from medical to dentist offices, state Medicaid programs may want to consider increasing the upper age limit for reimbursement of preventive oral health services provided in the medical office. This strategy may increase access to care and promote the oral health of children living in communities with few available dentists. Currently, 11 state Medicaid programs reimburse the application of fluoride varnish in medical offices for children aged 6 years and older.¹⁰ Additionally, expanding allied dental personnel and their

duties may help to alleviate barriers to dental care. In Alaska and throughout the world, dental therapists, midlevel dental providers who provide preventive and restorative treatments, have been used to improve access to dental care for children and for individuals living in remote communities.^{8,38} While dentist visits are important for monitoring potential problems and providing treatment, expanding the number and type of providers delivering oral health services may help to increase access to prevention for children at low-risk of developing ECC and also free up space in dentist offices for children with the greatest need.

This study has several limitations. This observational study may suffer from selection bias if there are unobserved factors influencing utilization of dentist and IMB visits. We attempted to adjust for selection bias that could arise because of observed systematic differences between children by estimating propensity scores and using IPTW, however, this method does not adjust for unobserved factors. Although use of data collected largely for administrative purposes limits availability of variables, we supplemented these data using publically available county-level measures relevant to this analysis. Our examination of only NC may limit generalizability of these results; however, more than 40 state Medicaid programs reimburse fluoride varnish delivered in medical offices.

Having a comprehensive and continuously accessible source of dental care is important for promoting young children's oral health. Although Medicaid programs reimbursing PCPs for preventive oral health services delivered in the medical office can increase access to prevention for young children, the transition to a dentist as children age-out of these programs may disrupt their continuity of dental care. Children with only IMB visits compared to dentist visits before age 3 experienced a significantly longer time a dentist visit after their third birthday. Strengthening referrals from physicians and expanding the

availability of dental providers could help ensure children are able to obtain treatment for dental problems and establish dental homes after they age-out of medical office-based preventive oral health programs.

Table 4.1. Description of Current Dental Terminology (CDT) codes used to identify preventive oral health services received during IMB visits

CDT Code	Description
D0150	Comprehensive oral evaluation
D0120	Periodic oral examination
D1203	Topical application of fluoride (Prophylaxis not included) for a child
D1201	Prophylaxis application of fluoride for a child
D1330	Oral hygiene instructions for a child
W8002	Initial oral screening
W8003	Periodic oral screening

CDT codes changed from “W” to “D” during the study period, but represent the same services. NC Medicaid policy required physicians to provide all three services (evaluation, hygiene instructions, and fluoride application) during the visit, identified by paid J claims.

Table 4.2. Characteristics of young children enrolled in NC Medicaid during 2000-2006 (n=95,578)

Variable description; mean (standard deviation)	Mode of delivery for oral health services before 3 years old		
	IMB only (N=60,124)	Dentist only (N=22,061)	Both IMB & dentist (N= 13,393)
Had a dental visit following third birthday (%)	44	69.6	66.2
Months from third birthday to dental visit (median)	22	8	7
<i>Past use of healthcare services</i>			
Number of well-child visits before age 3	4.52 (1.56)***	3.81 (2.02)	4.84 (1.54)***
Dental visit <6 months before 3rd birthday (%)	0.7***	19.6	22.6***
Received any oral health services received in FQHC before age 3 (%)	26.4***	17.7	36.9***
Child has special health care needs (%)	4*	4.3	4.4
Months enrolled in Medicaid before age 3	30.61 (2.15)***	30.46 (2.50)	30.63 (2.05)***
<i>Sociodemographic characteristics</i>			
Race (%)			
White	39***	34.6	36***
Black	37.9***	39.6	36***
Hispanic ethnicity (%)	13.2***	15.7	18***
Male (%)	51	51.2	52.4*
<i>Environmental factors</i>			
Proportion of children aged 0-18 years in county enrolled in Medicaid	0.24 (0.05)***	0.21 (0.06)	0.22 (0.05)***
Primary care providers per 10,000 population	4.37 (2.03)***	4.98 (2.23)	4.62 (2.17)***
Dentists per 10,000 population	3.82 (1.74)***	4.83 (1.98)	4.24 (1.89)***
Year turned 3 years old (%)			
2002	7.1	9.5	4.7
2003	20.2	21	15.4
2004	23.7	23.5	22.7
2005	25.1	24.3	27.3
2006	23.8	21.7	30

IMB, Into the Mouths of Babies preventive dental program; FQHC, Federally Qualified Health Center. We also examined each county's level of urbanization and proximity to metro area. Observed differences in variables between the children with only IMB visits vs. only dentist visits and children with both IMB and dentist visit vs. only dentist visits were examined using chi-squared tests to compare proportions and t-tests to compare means. ***P<0.001, **P<0.01, *P<0.05.

Table 4.3. Adjusted hazard ratios of time to dentist visit after third birthday for young children enrolled in North Carolina Medicaid

Compared to having only dentist visits before age 3	Adjusted Hazard Ratio	95% Confidence level
Model 1 IMB only	0.410***	(0.39, 0.43)
Model 2 Both IMB and dentist visits	0.990	(0.96, 1.03)

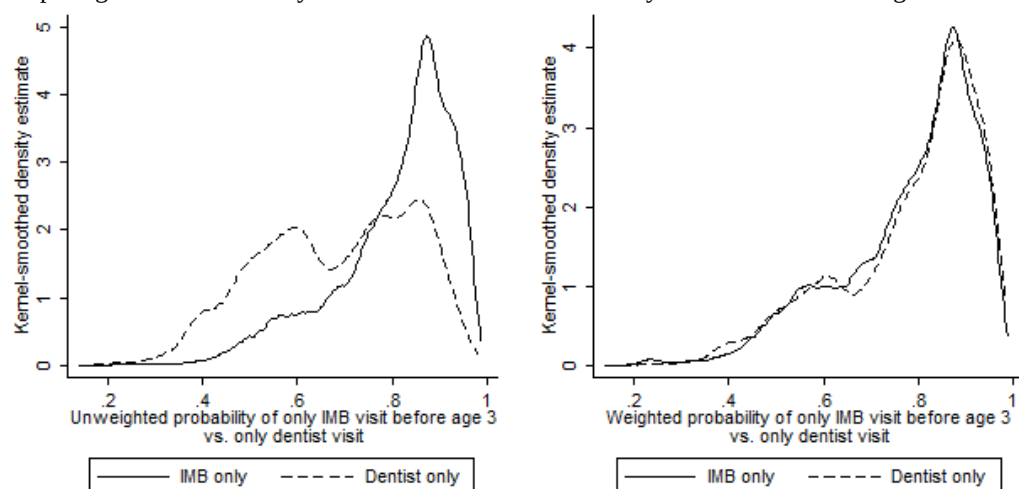
Effect of IMB conditional on number of dentists per 10,000 county population

Model 3 IMB only	Number of dentists		
	0	0.416***	(0.365, 0.475)
	1	0.420***	(0.371, 0.475)
	2	0.423***	(0.377, 0.476)
	3	0.427***	(0.382, 0.477)
	4	0.431***	(0.386, 0.48)
	5	0.434***	(0.39, 0.484)
	6	0.438***	(0.39, 0.488)
	7	0.442***	(0.395, 0.494)
	8	0.446***	(0.396, 0.501)
Model 4 Both IMB and dentist visits	0	0.985	(0.895, 1.083)
	1	0.996	(0.915, 1.085)
	2	1.008	(0.931, 1.093)
	3	1.020	(0.941, 1.107)
	4	1.032	(0.946, 1.127)
	5	1.045	(0.946, 1.153)
	6	1.057	(0.944, 1.184)
	7	1.070	(0.94, 1.218)
	8	1.082	(0.934, 1.255)

***P<0.001, **P<0.01, *P<0.05

Figure 4.1. Distribution of cohorts, pre- and post- adjustment using inverse probability weighting

A. Comparing children with only IMB visits to children with only dentist visits before age 3



B. Comparing children with both dentist and IMB visits to children with only dentist visit before age 3

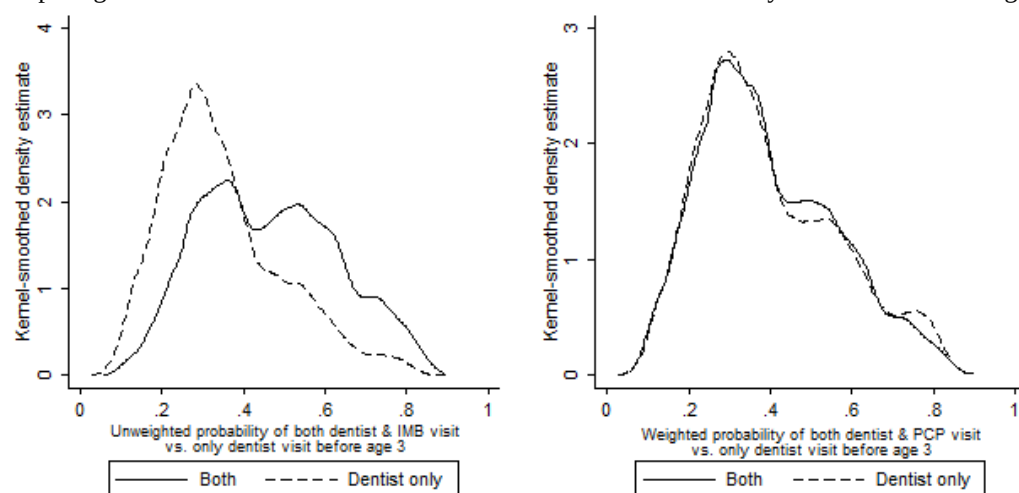
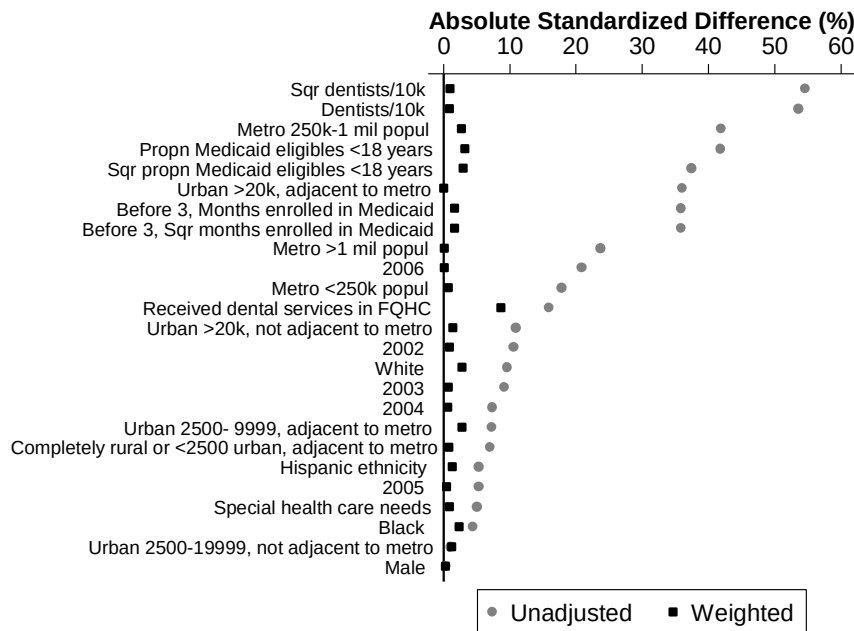


Figure 4.2. Difference in absolute standardized differences for covariates in the unadjusted and weighted samples

A. Comparing children with only IMB visits to children with only dentist visits before age 3



B. Comparing children with both dentist and IMB visits to children with only dentist visits before age 3

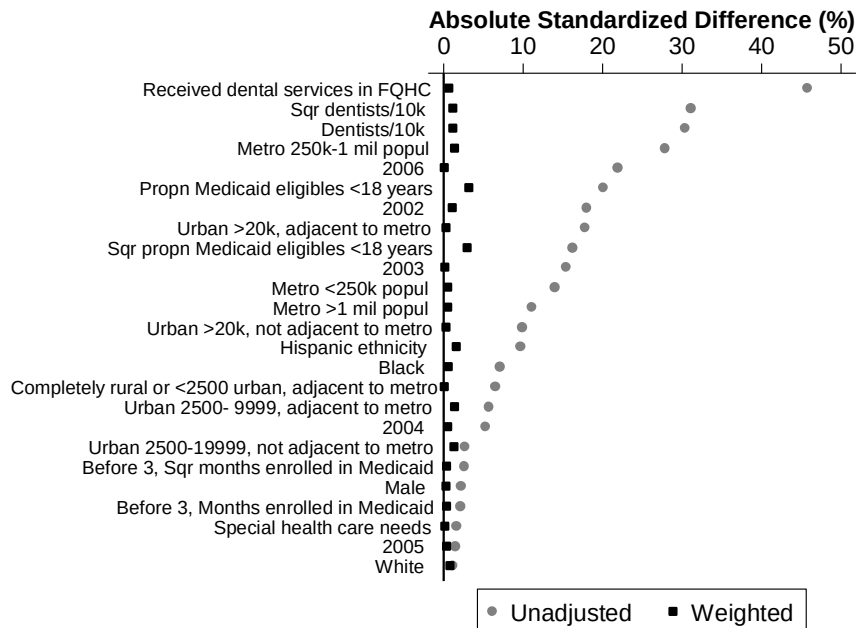
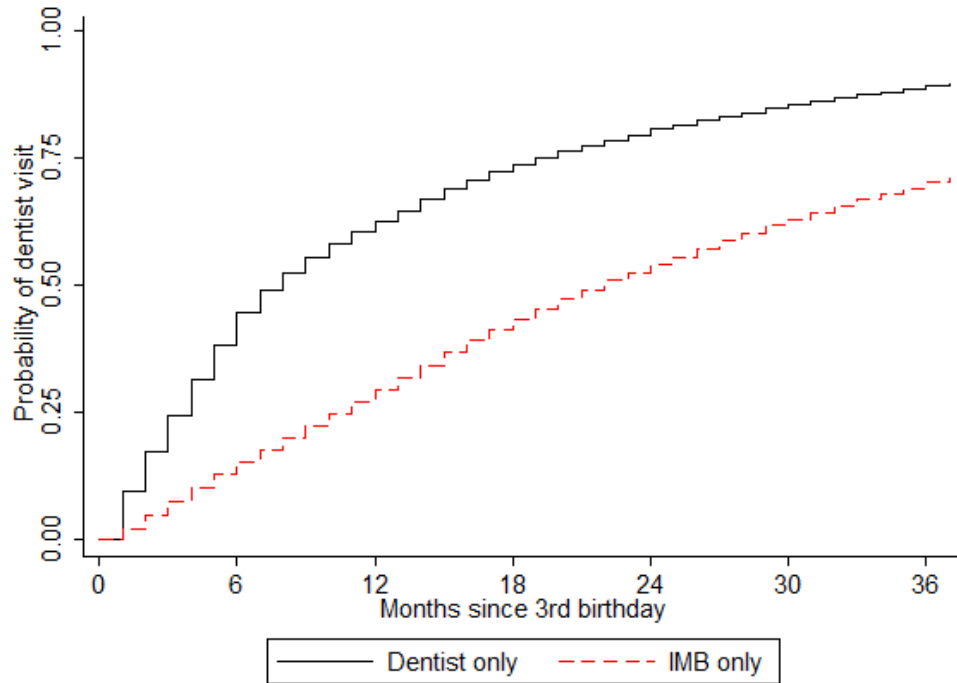
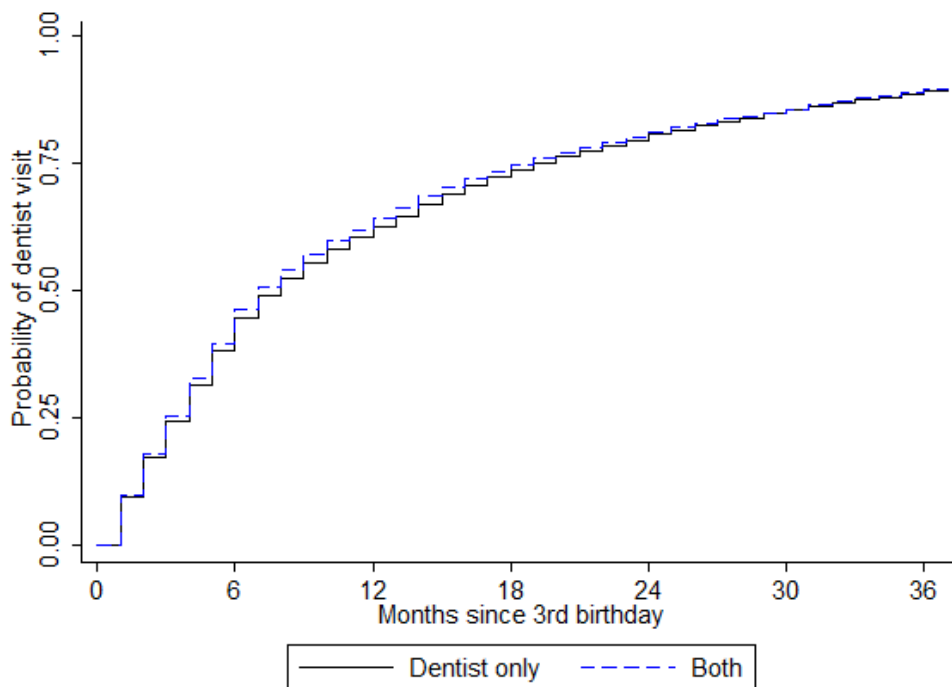


Figure 4.3. Cumulative IPTW adjusted probability of a dentist visit after 3 years of age

A. Children with only IMB visits vs. children with only dentist visits before age 3



B. Children with both dentist and IMB visits vs. children with only dentist visits before age 3



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5. Effect of different modes of delivery on caries-related treatments and associated payments during ages 3 to 5 years

5.1. Overview

Since 2000, North Carolina (NC) Medicaid has reimbursed preventive oral health services provided to young children in medical offices via the Into the Mouths of Babies (IMB) program. The objective of this study was to compare the effect of the provider of preventive oral health services on subsequent dental caries-related treatment (CRT) and payments for young Medicaid-enrollees. This was a retrospective study of young children enrolled in NC Medicaid during 2000 to 2006. We included children who received preventive oral health services before 3 years of age from IMB, dentists, both IMB and dentists, or neither. We examined the annual number of CRT and payments for children aged 3 to 5 years were estimated using a zero-inflated negative binomial regression and two-part regression, respectively. Models adjusted for relevant child- and county-level characteristics and used propensity score matching to address observed selection bias. We examined 159,435 children for an average of 2.5 years. Of 70,054 children receiving preventive oral health services before age 3, 71% had only IMB visits. Children who had dentist or both dentist and IMB visits before age 3 had significantly more CRT and higher payments per year during ages 3 to 5 than children who had only IMB visits or neither; however these differences attenuated each year after age 3. In conclusion, delivering preventive oral health services by PCPs can increase access to prevention. Having only IMB visits was associated with fewer CRT and lower payments. Additional research is needed to confirm if this is due

to improved oral health or poor access to dental treatment.

5.2. Introduction

Early childhood caries (ECC), or tooth decay in young children, is prevalent in the United States, as over 25% of children aged 0 to 5 years old have ECC.¹ In addition to causing pain and decreased quality of life, ECC is costly to treat.² In 2006, Medicaid paid for 53% of children's hospital-based emergency department visits attributed to dental caries totaling \$14.33 million.³ For children under 6 years of age enrolled in North Carolina (NC) Medicaid, the average predicted payment for a dental caries-related treatment (CRT) episode ranges from \$334 for an office visit to \$3,051 for a hospital visit.⁴ Compared to children from higher-income families, children living in poverty are more likely to have dental caries, but less likely to receive treatment.¹ This difference is due in part to access to care, which is negatively affected by dental workforce shortages and dentists' low rate of participation in Medicaid.^{5,6}

State Medicaid programs have sought to improve young children's access to preventive oral health services by reimbursing primary care providers (PCPs) for applying fluoride varnish in the medical office. Since 2000, NC's Into the Mouths of Babies (IMB) program has trained PCPs to provide oral health counseling to parents, conduct an open-mouth evaluation, and apply fluoride varnish to children younger than 3 years of age.⁷ IMB services may be provided at either well- or sick- child visits, although it is suggested they coincide with well-child visits occurring at 6, 9, 12, 15, 18, and 24 months of age. Children suspected of having ECC or assessed to be at elevated risk are referred to dentists when they are available in the community. The IMB program, as well as similar programs in other

states, has helped increase access to preventive dental services and improved the oral health of young children enrolled in Medicaid.⁸⁻¹⁰

Prior studies suggest that IMB reduces dental CRT. Children who received 4 or more IMB visits compared to no IMB visits had a lower likelihood of receiving CRT in both hospital and office settings and a 17% reduction in CRT up to 6 years of age.^{4,9} Additionally, having 4 or more IMB visits was associated with lower Medicaid payments for hospital or dentist office treatments, suggesting fewer treatments within a treatment episode.⁴ While these findings suggest IMB visits promote oral health, these studies did not control for preventive services received from dentists or examine whether IMB visits promote oral health as well as visits to dentists, the conventional provider of these services.

Today, nearly all state Medicaid programs reimburse preventive oral health services delivered by PCPs in the medical office.¹¹ As both the number of PCPs providing preventive oral health services and the number of children eligible for Medicaid increases, it becomes increasingly important to compare the effect of preventive oral health services delivered by PCPs to dentists.¹² To understand how the type of provider of preventive oral health services affects subsequent rates of dental treatment, we compared children who received only IMB visits, only dentist visits, both IMB and dentist visits, and neither before 3 years of age regarding the number of CRT received and payment for these treatments during 3 to 5 years of age. Children who received preventive oral health services during IMB or dentist visits before 3 years of age are expected to benefit from early screenings, anticipatory guidance and applications of fluoride varnish.^{13,14} Therefore, we hypothesized that these children will have a similar number of dental CRT and payments during ages 3-5 years as each other, but fewer CRT and lower payments than children who did not receive any prevention before age 3.

Because children who have early dentist visits may do so to obtain treatment or because they are at increased risk of ECC, we also considered that our results may reflect this unobserved risk status and indicate that early dentist visits are associated with more CRT. Furthermore, because the IMB program instructs PCPs to refer children with existing dental disease to dentists, and having decay at an early age is a strong predictor of subsequent decay, we hypothesized that children who received both IMB and dentist visits before 3 years of age will have higher CRT rates and payments than children had only IMB or only dentist visits before age 3.¹⁵

5.3. Methods

We conducted a retrospective study to examine the effect of the provider delivering preventive oral health services before 3 years of age on children's subsequent CRT and associated payments.

5.3.1. Construction of analytical sample

We used NC Medicaid enrollment and claims files from the NC Division of Medical Assistance from 2000-2006. These files provide information about Medicaid enrollment, demographic characteristics, the type of procedure received, the amount paid for the procedure, the procedure setting, and the type of provider submitted the claim (e.g., dentist or physician). We included children who were enrolled in the NC Medicaid program before 1 year of age, enrolled for at least 12 months before their third birthday, and enrolled for at least 8 months following their third birthday to allow time to observe the outcomes. Children were excluded from the analysis if they had IMB claims post-eligibility (n=156), treatment but no observed payments or the converse (n=251). The study sample included 393,562 child-year observations for 159,422 children 3 to 5 years of age.

5.3.2. Variable definitions

We examined two outcomes: CRT and total payments for CRT. The total number of CRT received per year for children aged 3, 4, and 5 years was identified using Current Dental Terminology (CDT) codes beginning with D2, D3, D4, D5, D6, D7, D8, and D9; these include amalgam restorations, composite restorations, extractions, crowns, and nerve-related treatments (pulpotomies/pulpectomies). Treatment could be received in both hospital and office-based settings. Payment for CRT was identified in Medicaid claims and summed to estimate annual treatment payments for ages 3, 4, and 5 years. To account for inflation over the study period, treatment payments were adjusted to constant 2006 U.S. dollars using the Gross Domestic Product price index, which includes expenditures from federal, state, and local governments.¹⁶

Our main treatment, provider type for preventive oral health services before age three, was operationalized as a 4-category variable: IMB visits only, dentist visits only (*reference group*), both dentist and IMB visits, and neither. We chose age three because during the study period Medicaid reimbursed PCPs for up to 6 IMB visits before age three. IMB visits were identified with paid claims filed by physicians for preventive oral health services. A visit in a dentist office with preventive services, reimbursed by Medicaid up to twice annually, was defined as having paid claims for a comprehensive or periodic evaluation with fluoride. CDT codes used to identify visits with preventive oral health services are provided in Table 5.1. Some dentist visits included CRT because we did not attempt to identify the purpose of the visit.

We included the following additional child- and county-level characteristics measured at or before 3 years of age:

- Child-level: sex, race [white, black, other (reference)], Hispanic ethnicity, number of well-child visits, total months enrolled in Medicaid per year for each age (i.e., during ages 3, 4, and 5 years), indicators of special health care needs, whether any preventive oral health services were received in a Federally Qualified Health Center, health department, or rural health clinic, year treatment was received.
- County-level: proportion of population with access to fluoridated public drinking water¹⁷, indicators of rural or urban status¹⁸, and the number of dentists, pediatricians and family practice physicians¹⁹, and Medicaid eligible children younger than 18 years per 10,000 population.²⁰

5.3.3. Analytic strategy

We were concerned about selection bias that may arise due to differences between children with and without dentist visits because it is unknown if these visits are for existing disease or demand for preventive services. To address this possible selection bias, we utilized propensity score matching. The goal of propensity score matching is to obtain a sample that is as similar as possible, differing only in their exposure to treatment, which in this case is the provider of preventive oral health services before age three.²¹ By assuming that individuals with similar propensity scores have the same distribution of covariates regardless of treatment group, we can obtain an unbiased estimate of the average treatment effect on the treated.²² Estimates obtained using propensity scores rely on the assumption that the model used to estimate the propensity score is correctly specified, meaning all important differences between children are explained by the covariates included in the model. Additionally, matching is beneficial in that it should make the effect estimates less sensitive to model specification.²³

Propensity score matching methods typically used for a two-group treatment variable were adapted for this analysis of a four-group treatment variable (type of provider).²²

Because we have four groups with four different sample sizes, we used a three-stage matching strategy to obtain an analytical sample with a similar distribution of covariates across all groups. Propensity scores were estimated using logistic regression and controlled for the aforementioned covariates, including squared terms of continuous variables and total

Dentist visits	IMB visits		
		No	Yes
	No	A	B
	Yes	C	D

number of months enrolled in Medicaid from initial enrollment to the child's third birthday.

First, we estimated the likelihood of having an

IMB visit before age 3 for children who received only IMB visits or no preventive oral health services before age 3 (groups A and B) because these two groups have the largest number of observations. We excluded from matching children having propensity score values beyond the region of common support (i.e., having values outside the range of the other group).²² For this and all subsequent matches, we used the user written Stata program PSMATCH2 and performed single nearest neighbor matching using a caliper equal to 0.20 of the standard deviation of the propensity score. Second, we estimated the likelihood of having a dentist visit only before age 3 for children who received only dentist visits or both dentist and IMB visits before age 3 (groups C and D) because these two groups have the fewest observations. We excluded children beyond the common support region and performed single nearest neighbor matching. Using only the matched observations stemming from these two regression models (7.2 A and B observations per 1 C and D observation), we then estimated the likelihood of having a dentist visit (with or without IMB visits) before age 3. We excluded children beyond the common support region and performed single nearest neighbor

matching. To evaluate covariate balance in the final matched sample across our four-group key explanatory variable, we compared the distribution of propensity scores from the final regression model in the full and matched samples. Additionally, we examined changes in absolute standardized differences of variables across treatment groups in the full and matched samples.²⁴

A zero-inflated negative binomial regression was used to estimate the total number of dental CRT received per year per child for ages 3, 4, and 5 years old, a model appropriate for a count dependent variable with excess zeros.²⁵ This model included an offset term equal to the logged number of months the child was enrolled in Medicaid at each age. Annual Medicaid payments for CRT at ages 3, 4, and 5 years were estimated using a two-part regression model, which is appropriate for a continuous dependent variable with excess zeros.²⁶ First, a logistic regression model was used to estimate the likelihood of having any treatment payments during a year. Second, an Ordinary Least Squares (OLS) regression model was used to estimate the expected treatment payments during each age for children having any CRT in a given year. These results were transformed using a smearing estimator for heteroskedastic and normal errors. Estimates from the logistic and OLS regression models were combined using 200 bootstrap replications to obtain an estimate of the expected annual payments for children aged 3 to 5 years receiving preventive oral health services during IMB visits, dentist visits, both IMB and dentist visits, and neither. Regression models controlled for the aforementioned covariates. Standard errors were clustered at the child-level to adjust for repeat observations over time. Mean expected values for each outcome were calculated for the full sample for children receiving preventive oral health services before age 3 from different providers. Differences in mean expected outcomes were examined using

Wald tests and 95% confidence intervals. Analyses were performed in Stata/IC 12 (Statacorp, College Station, TX) using a 0.05 significance level. This study was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill.

5.4. Results

The 159,422 eligible children were followed for an average of 2.5 years (Table 5.2). Most children did not receive preventive oral health services before age 3 (n=89,373). Of the children receiving prevention before age 3, 13,110 (19%) had only dentist visits, 49,885 (71%) had only IMB visits, and 7,054 (10%) had both IMB and dentist visits. Thirty-two percent of children received any dental treatment during ages 3 to 5 years. On average, children who received only IMB visits had more well-child visits and lived in areas with fewer dentists than children who received only dentist visits before age 3.

5.4.1. Propensity score matching

To obtain a sample with covariates balanced across the four provider type categories of our treatment variable, we used a three-stage matching strategy. Results of the three logistic regression models used to construct the propensity score matched sample are provided in supplemental table 2. First, we estimated the likelihood of having only IMB visits compared to no preventive oral health services before age 3 for 139,259 children. We excluded from matching 5,333 children who had propensity score values beyond the region of common support (i.e., having values outside the range of the other group). Using single nearest neighbor matching, we obtained 44,553 matched pairs (n=89,106). Second, we estimated the likelihood of having only dentist visits compared to both IMB and dentist visits before age 3 for 20,164 children. We excluded 6,949 children beyond the region common support and obtained 6,161 matched pairs (n=12,322). Third, we included only the matched

observations from the prior two models (n=101,428) and estimated the likelihood of having a dentist visit (with or without IMB) before age 3. No children had propensity scores beyond the region common support. Using single nearest neighbor matching, we obtained a final sample size of 24,644 children. Propensity scores from the final regression model and variable means across the four groups identifying the provider of preventive oral health services before age 3 were more similar in the matched sample than the unmatched sample. Matching improved balance of covariates between each of the four-groups as evidenced by differences of less than 10% in absolute standardized differences for covariates (Figure 5.1). Regression results from the full and matched samples were similar in magnitude and significance, therefore we present results from only the matched sample.

5.4.2. Expected number of treatments

The results of the zero-inflated negative binomial regression are provided in Table 5.3. For ease of interpretation, predicted mean treatments per year are presented in Figure 5.2. Children with only dentist visits or both dentist and IMB visits before age 3 had significantly more CRT per year than children having only IMB visits; however, these differences attenuated each year after age 3 (Figure 5.2). The annual number of CRT decreased 44% and 40%, respectively, from age 3 for children who had only dentist visits or both dentist and IMB visits before age 3. Children who had only IMB visits before age 3 experienced a 24% increase in CRT from ages 3 to 5 years. At 5 years of age mean annual CRT ranged from 0.92 for children with no visits before age 3 to 1.11 for children who had both IMB and dentist visits before age 3.

5.4.3. Expected payment for treatment

The results of the two-part regression model are provided in Table 5.4. For ease of interpretation, the predicted mean annual probability of having any payments for dental CRT and predicted mean annual payment are presented in Figure 5.3. As depicted in Figure 5.3A, the probability of having any payments for CRT was lowest but similar for children who had only IMB visits or no visits with prevention, but increased slightly with age. For children who had only IMB visits before age 3, the probability of having any payments for CRT increased by 67% from 3 to 5 years of age. For children who received preventive oral health services during only dentist visits or both dentist and IMB visits before age 3, the probability of having any payment for CRT in a year was relatively constant at an average of 0.29 during ages 3 to 5 years. Expected annual payments for children having any CRT (Figure 5.3B) were slightly higher for children with only IMB visits or no visits with prevention before 3 years of age. At 4 years of age, expected payments were \$887 for no visits, \$869 for IMB visits only, \$741 for dentist visits only, and \$726 for both. For all children receiving CRT, annual payments declined about 33% from age 3 to 5 years.

Mean annual Medicaid payments for dental CRT, calculated by multiplying the probability of having any annual payments and the expected annual payment conditional on having CRT, were lowest for children who had only IMB visits and children who did not receive preventive oral health services before age 3 (Figure 5.4). For children who received prevention during only dentist visits or both dentist and IMB visits before age 3, highest treatment payments occurred at 3 years of age (\$272 and \$286), but decreased 44% and 41%, respectively, by age 5. Payments for children who had only IMB visits or no visits before age

3 increased by 7% and 5%, respectively, from ages 3 to 5. At 5 years of age, CRT payments by type of provider of preventive oral health services were not significantly different.

5.5. Discussion

Young children encounter difficulty accessing dental care, which contributes to increasing rates of dental caries that disproportionately affect infants and toddlers living in poverty.¹ Recognizing that young children make more visits to medical offices than dentist offices, most state Medicaid programs now reimburse PCPs to deliver preventive oral health services.¹¹ To understand how the type of provider delivering preventive oral health services may be associated with subsequent rates of CRT and payments, we compared children who received only IMB visits, only dentist visits, both IMB and dentist visits, and neither before 3 years of age.

We found that on average children who had only IMB visits or no prevention before 3 years of age received fewer CRT and had lower CRT payments than children who received preventive oral health services from dentists. This differed from our expectation that preventive oral health services delivered during IMB and dentist visits before 3 years of age should prevent decay and lead to comparable reductions in CRT. Because we do not have clinical measures of oral health status, we cannot conclude if our finding of fewer CRT among children who had only IMB visits indicates better oral health. Therefore, these findings suggest that the IMB program is associated with a reduction in CRT by preventing decay and/or because these children have poor access to dental treatment.

IMB visits may lead to a greater reduction in decay than dentist visits because of children's increased opportunity to receive multiple applications of fluoride varnish in the medical office, which can prevent caries, especially when applied as new teeth emerge.^{4,27-29}

While Medicaid reimburses preventive visits in a dentist office up to twice per year, IMB services are currently reimbursed up to 6 times before 36 months of age. Children with only IMB visits before age 3 had more visits with preventive oral health services on average than children with only dentist visits (IMB only=2 visits; Dentist only=1.4 visits). Due to this current reimbursement model and because young children are more likely to visit medical offices than dental offices, IMB and similar programs could provide more opportunities to reduce dental caries than compared to dentist visits alone.

Despite the benefit of multiple applications of fluoride varnish, our findings may indicate that the reduction in CRT associated with IMB visits may not be due to preventing decay, but rather children's poor access to dental treatment. The IMB program was initiated to improve access to preventive oral health services for young children encountering challenges to dentist visits. Although dentists report being more willing to accept older children as patients, as children age other barriers such as workforce shortages and dentists' low rate of participation in Medicaid remain as barriers to dental care.^{30,31} A prior study reported that the likelihood of a dentist visit before age 3 was negatively related to county-level rate of IMB implementation in rural counties, where dental workforce shortages are most pronounced.¹⁰ We observed that at age 3, children who had only IMB visits had the lowest probability of receiving dental CRT but the highest expected payments of children receiving treatment, suggesting that extensive treatment is being received by a select group of children. If some children who received only IMB visits did so because they were unable to obtain a dentist visit, then it is possible that untreated dental problems may ultimately compound and lead to more extensive and costly treatment.

This observational study may suffer from selection bias if there are unobserved factors affecting children's selection of the provider of preventive oral health services. For example, the IMB program may be associated with fewer CRT and lower payments than dentist visits due to the case-mix of children utilizing each setting of care. It is possible that children who had only IMB visits before 3 years of age were at low-risk of developing ECC and thus waited to visit a dentist. Beil and colleagues reported that most children could likely delay their first dentist visit until 3 years of age without experiencing additional problems; however, when the dental workforce is constrained, they recommended early dentist visits for children with existing dental disease and those at highest risk for developing disease.³² We attempted to adjust for selection bias that could arise because of systematic differences between children by using propensity score matching, however, this method does not adjust for unobserved differences between children that may exist both before and after age 3.

Some children who received preventive oral health services from a dentist before their third birthday may have sought care or been referred due to existing disease or being at elevated risk for developing ECC. Because past dental caries experience is a strong predictor of future dental disease, we would expect these high-risk children to receive more CRT and have higher payments later on than children without prior caries.¹⁵ A referral from a PCP for existing disease may help explain why children who had both IMB and dentist visits before age 3 received more dental CRT than children who had only IMB visits. A prior evaluation of the IMB program found evidence of a referral effect, as children with and without IMB visits received a similar number of CRT during 18 to 39 months of age, a time that coincides with their eligibility for IMB. Although our administrative data cannot identify children who received referrals, 99% of these children had an IMB visit before their first dentist visit,

suggesting that a referral may have played a role in many of these dentist visits. This physician referral behavior is in line with American Academy of Pediatrics guidelines recommending that physicians, when faced with a limited dental workforce, immediately refer young children suspected to have ECC and provide preventive oral health services in the medical office for low-risk children until a regular dental provider can be established.³³

Although clinical measures would provide a more sensitive measure of oral health status, our examination of CRT and associated payments provides information about the extent of treatment received. We supplemented these administrative data with publically available county-level measures relevant to this analysis; however, additional information about children, such as brushing practices and dietary habits, would help us to better understand utilization decisions and treatment outcomes. Furthermore, our matched sample included about 15.5% of our full sample and therefore may not be representative of the true population of young children enrolled in NC Medicaid. Compared to the matched sample, children in the full sample had on average fewer well-child visits before age 3, were less likely to receive oral health services in an FQHC, and had a greater likelihood of having a dentist visit with preventive oral health services before age 3. However, the matched sample was limited to children who differed, based on observed covariates, only on the setting and provider of preventive oral health services before 3 years old, which enabled us to estimate an unbiased treatment effect. Moreover, results from the full and matched samples were similar in magnitude and significance. While findings from this study may have limited generalizability because the data were from a single state, more than 40 state Medicaid programs reimburse fluoride varnish delivered in medical offices.¹¹ Thus, these findings are

pertinent for low-income children throughout the country and have the potential to lessen oral health disparities among children.

The provision of preventive oral health services by PCPs through the IMB program was associated with an increase in the number of children younger than 3 years old receiving prevention. Compared to children who visited only dentists before age 3, children who had only IMB visits received fewer dental CRT and had lower payments on average during ages 3 to 5 years. Additional research using clinical outcome measures is needed to confirm the extent to which children who received only IMB visits have fewer CRT and lower payments due to improved oral health, poor access to dental treatment, or a combination of both factors.

Table 5.1. Description of Current Dental Terminology (CDT) codes used to identify preventive oral health services received during dentist and IMB visits

Identifies visit type:	CDT Code	Description
IMB & Dentist	D0150	Comprehensive oral evaluation
IMB & Dentist	D0120	Periodic oral examination
IMB & Dentist	D1203	Topical application of fluoride (Prophylaxis not included) for a child
IMB & Dentist	D1201	Prophylaxis application of fluoride for a child
IMB	D1330	Oral hygiene instructions for a child
IMB	W8002	Initial oral screening
IMB	W8003	Periodic oral screening

CDT codes changed from “W” to “D” during the study period, but represent the same services.
 NC Medicaid policy required physicians to provide all three services (evaluation, hygiene instructions, and fluoride application) during the IMB visit, identified by paid J claims.
 Preventive visit in a dental office was defined as paid K claims for a comprehensive or periodic evaluation with fluoride. IMB – Into the Mouths of Babes.

Table 5.2. Baseline characteristics of NC Medicaid-enrollees aged 3 to 5 years (N= 159,422)

Variable description; mean (standard deviation)	All (n=159,422)	Setting for preventive oral health services before 3 years old			
		Neither (n=89,373)	Dentist visits only (n=13,110)	IMB visits only (n=49,885)	Both dentist & IMB visits (n=7,054)
Dependent variables					
Annual number of dental treatments***	1.0 (3.1)	0.9 (3.1)	1.5 (3.4)	0.9 (3.0)	1.5 (3.5)
Percent of children with any dental treatment during ages 3 to 5 years***	32	29.9	49.9	28.4	49.6
Annual payment for dental treatment***	190.3 (905.1)	180.4 (891.4)	254.0 (965.2)	180.3 (894.4)	275.4 (1031.3)
Explanatory variables					
<i>Child-level characteristics</i>					
Number of months enrolled in Medicaid per year***					
3 years of age	11.6 (1.5)	11.6 (1.5)	11.6 (1.5)	11.6 (1.5)	11.6 (1.4)
4 years of age	9.8 (3.6)	10.0 (3.5)	9.5 (3.7)	9.5 (3.7)	9.2 (3.9)
5 years of age	9.1 (3.8)	9.3 (3.7)	8.8 (3.9)	8.8 (3.9)	8.2 (4.0)
Race (%)***					
White	38.5	39.6	31.7	38.8	33.8
Black	39.5	39.8	41.8	38.4	39.2
Hispanic ethnicity (%)***	12.9	11.9	16.5	12.9	17.9
Male (%)**	50.9	50.6	50.7	51.1	52.6
Special healthcare needs (%)	4	3.9	3.8	4.2	3.9
Number of well-child visits before 3 years of age***	3.6 (1.9)	3.2 (1.9)	3.6 (2.0)	4.4 (1.5)	4.6 (1.5)
Oral health services received in FQHC (%)***	10.8	9.2	11.7	12.7	15.9
Year child turned 3 years old***					
2002	0.1	0.2	0.1	0.1	0.1
2003	13.7	17.2	10.9	9.2	5.5
2004	40.8	47	35.2	33.4	24.4
2005	64.9	69.1	60.9	60	53
2006	79.4	74.7	83.6	85.1	90.1
<i>County-level characteristics</i>					
Medicaid eligibles younger than 18 years per 10,000 population***	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)
Dentists per 10,000 population***	4.1 (1.9)	4.2 (1.9)	4.9 (1.9)	3.7 (1.7)	4.3 (1.8)
Primary care providers per 10,000 population***	4.5 (2.0)	4.6 (2.1)	4.9 (2.1)	4.3 (1.9)	4.6 (2.1)

Explanatory variables not presented in this table include the rural/urban status of the child's county of residence and the percent of the county population with fluoridated drinking water. FQHC - Federally Qualified Health Center.

P-values by ANOVA for continuous variables and chi2 test for binary / categorical variables. ***P<0.0001; **P<=0.01

Table 5.3. Results of zero-inflated negative binomial regression estimating annual number of caries-related treatments for propensity score matched sample

	Results of logit regression estimating likelihood of any treatment in a year			Results of negative binomial regression estimating expected number of treatments conditional on having any treatments in a year		
	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
Mode of delivery for preventive oral health services before age 3 (reference group: dentist only)						
None	1.273	0.054	0.000	0.204	0.045	0.000
IMB only	1.335	0.055	0.000	0.216	0.045	0.000
Both dentist and IMB	-0.121	0.049	0.013	0.000	0.036	0.989
Age in years (reference group: 3 years old)						
4 years	-0.007	0.051	0.884	-0.076	0.045	0.091
5 years	-0.107	0.070	0.126	-0.294	0.053	0.000
Delivery mode * Age						
None * age 4	-0.509	0.073	0.000	0.018	0.071	0.800
None * age 5	-0.801	0.096	0.000	0.038	0.086	0.659
IMB only * age 4	-0.528	0.075	0.000	0.089	0.077	0.248
IMB only * age 5	-0.797	0.098	0.000	0.174	0.090	0.054
Both * age 4	-0.005	0.070	0.943	0.000	0.061	0.999
Both * age 5	-0.045	0.095	0.633	0.052	0.074	0.482
Indicators of race and ethnicity						
White	0.422	0.045	0.000	-0.015	0.033	0.650
Black	0.356	0.046	0.000	-0.079	0.033	0.018
Hispanic	0.056	0.028	0.048	0.043	0.022	0.048
Male	-0.253	0.050	0.000	0.040	0.034	0.233
Indicator that child has special healthcare needs	0.387	0.075	0.000	0.090	0.058	0.125
Number of well-child visits before 3 years of age	-0.046	0.010	0.000	-0.023	0.008	0.003
Indicator that any oral health services before age 3 were received in FQHC	-0.544	0.060	0.000	-0.772	0.045	0.000
Number of Medicaid eligibles younger than 18 years per 10,000 population	0.588	0.444	0.186	0.938	0.353	0.008
Number of dentists per 10,000 population	0.028	0.013	0.037	-0.069	0.010	0.000
Number of primary care providers per 10,000 population	-0.025	0.010	0.016	0.024	0.008	0.003
Indicator of county's rurality (reference: completely rural or <2500 urban, not adjacent to metro)						

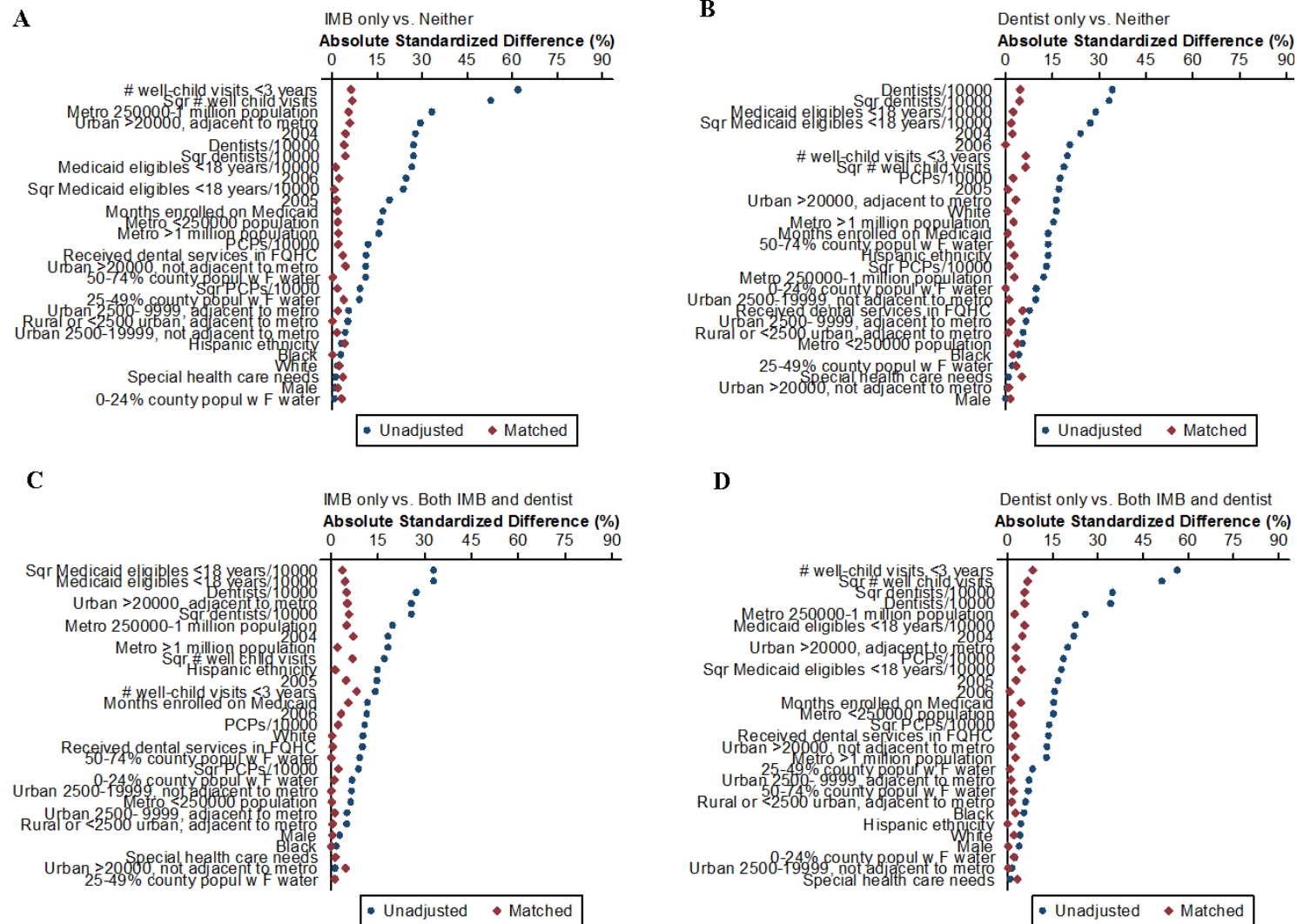
Metro >1 million population	0.020	0.129	0.877	0.119	0.103	0.247
Metro 250000-1 million population	-0.041	0.122	0.736	0.190	0.099	0.053
Metro <250000 population	0.106	0.129	0.411	0.083	0.105	0.430
	Results of logit regression continued			Results of negative binomial regression continued		
	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
Urban >20000, adjacent to metro	0.056	0.122	0.648	0.147	0.099	0.139
Urban >20000, not adjacent to metro	0.600	0.187	0.001	0.171	0.169	0.313
Urban 2500- 9999, adjacent to metro	0.079	0.122	0.518	0.208	0.097	0.033
Urban 2500-19999, not adjacent to metro	-0.154	0.188	0.412	-0.255	0.139	0.066
Completely rural or <2500 urban, adjacent to metro	0.147	0.158	0.351	-0.062	0.141	0.658
Size of county population with fluoridated drinking water (reference group: 75% or more)						
0-24%	0.059	0.085	0.487	0.266	0.071	0.000
25-49%	-0.062	0.078	0.430	0.141	0.060	0.019
50-74%	0.027	0.064	0.672	0.171	0.049	0.000
Year child turned 3 years old (reference group: 2002 or 2003)						
2004	-0.058	0.077	0.451	-0.143	0.070	0.042
2005	-0.183	0.077	0.018	-0.195	0.067	0.004
2006	-0.087	0.079	0.271	-0.187	0.067	0.005
Constant term	0.297	0.196	0.129	-0.868	0.158	0.000
	Child-year observations: 57391			Child-year observations with some treatment: 12970		
	Children: 24644			Children with some treatment: 9632		

Table 5.4. Results of two-part regression estimating annual payment for caries-related treatment for propensity score matched sample

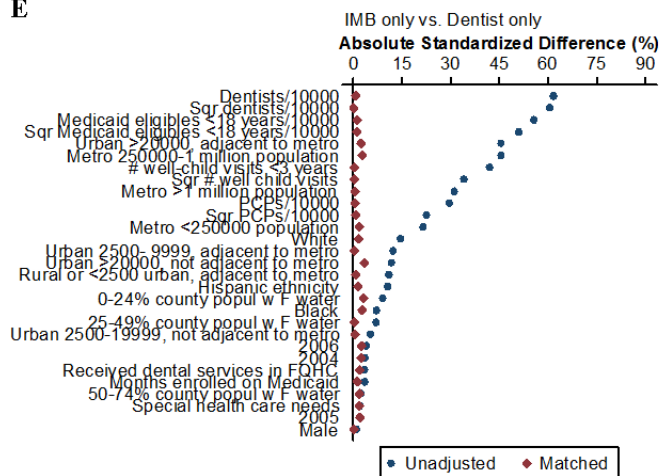
	Results of logit regression estimating likelihood of any treatment in a year			Results of OLS regression estimating expected logged payment for treatment conditional on having any treatments in a year		
	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
Mode of delivery for preventive oral health services before age 3 (reference group: dentist only)						
None	-1.112	0.047	0.000	0.160	0.053	0.002
IMB only	-1.161	0.048	0.000	0.261	0.054	0.000
Both dentist and IMB	0.099	0.039	0.012	-0.013	0.038	0.724
Age in years (reference group: 3 years old)						
4 years	0.120	0.040	0.003	-0.143	0.041	0.000
5 years	0.185	0.053	0.000	-0.347	0.048	0.000
Delivery mode * Age						
None * age 4	0.508	0.062	0.000	0.019	0.071	0.784
None * age 5	0.791	0.077	0.000	0.001	0.077	0.985
IMB only * age 4	0.550	0.064	0.000	-0.101	0.075	0.177
IMB only * age 5	0.838	0.079	0.000	-0.025	0.078	0.753
Both * age 4	-0.004	0.055	0.937	-0.007	0.056	0.903
Both * age 5	0.031	0.069	0.655	0.021	0.062	0.736
Indicators of race and ethnicity						
White	-0.369	0.038	0.000	0.035	0.032	0.265
Black	-0.350	0.038	0.000	-0.055	0.031	0.072
Hispanic	-0.036	0.023	0.122	0.032	0.020	0.113
Male	0.226	0.041	0.000	-0.004	0.031	0.903
Indicator that child has special healthcare needs	-0.352	0.065	0.000	0.291	0.066	0.000
Number of well-child visits before 3 years of age	0.030	0.008	0.000	-0.016	0.007	0.028
Indicator that any oral health services before age 3 were received in FQHC	0.084	0.039	0.030	-0.659	0.033	0.000
Number of Medicaid eligibles younger than 18 years per 10,000 population	-0.164	0.371	0.658	1.053	0.354	0.003
Number of dentists per 10,000 population	-0.043	0.011	0.000	-0.056	0.010	0.000
Number of primary care providers per 10,000 population	0.026	0.008	0.002	0.025	0.007	0.001

	Results of logit regression continued			Results of OLS regression continued		
	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
Indicator of county's rurality (reference: completely rural or <2500 urban, not adjacent to metro)						
Metro >1 million population	0.066	0.107	0.540	0.167	0.119	0.159
Metro 250000-1 million population	0.126	0.102	0.217	0.230	0.116	0.047
Metro <250000 population	-0.072	0.108	0.507	0.122	0.118	0.303
Urban >20000, adjacent to metro	-0.003	0.102	0.977	0.177	0.116	0.127
Urban >20000, not adjacent to metro	-0.496	0.154	0.001	0.139	0.166	0.400
Urban 2500- 9999, adjacent to metro	0.007	0.102	0.948	0.266	0.116	0.022
Urban 2500-19999, not adjacent to metro	0.091	0.156	0.560	-0.308	0.136	0.024
Completely rural or <2500 urban, adjacent to metro	-0.124	0.132	0.348	-0.137	0.152	0.366
Size of county population with fluoridated drinking water (reference group: 75% or more)						
0-24%	0.026	0.069	0.704	0.498	0.082	0.000
25-49%	0.105	0.066	0.112	0.026	0.060	0.661
50-74%	0.036	0.054	0.506	0.202	0.053	0.000
Number of months enrolled in Medicaid	0.171	0.004	0.000	0.036	0.004	0.000
Year child turned 3 years old (reference group: 2002 or 2003)						
2004	-0.044	0.067	0.509	-0.066	0.073	0.365
2005	0.013	0.066	0.845	-0.043	0.070	0.537
2006	0.071	0.067	0.290	-0.062	0.070	0.375
	Child-year observations: 57391			Child-year observations with some treatment: 12970		
	Children: 24644			Children with some treatment: 9632		

Figure 5.1. Change in absolute standardized differences for covariates in full and matched samples according to provider of preventive oral health services



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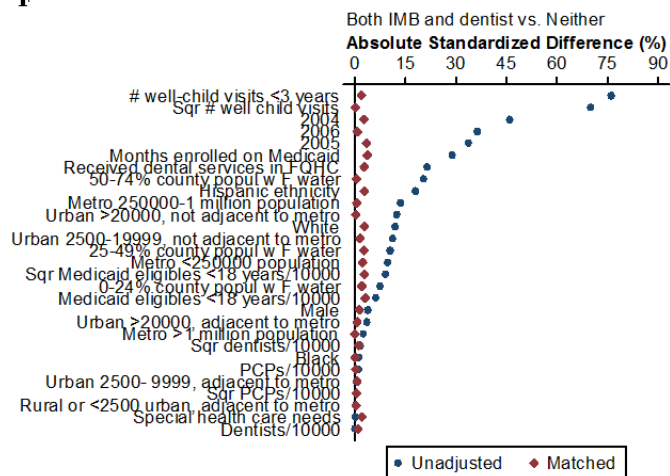


Figure 5.2. Predicted number of treatments per year

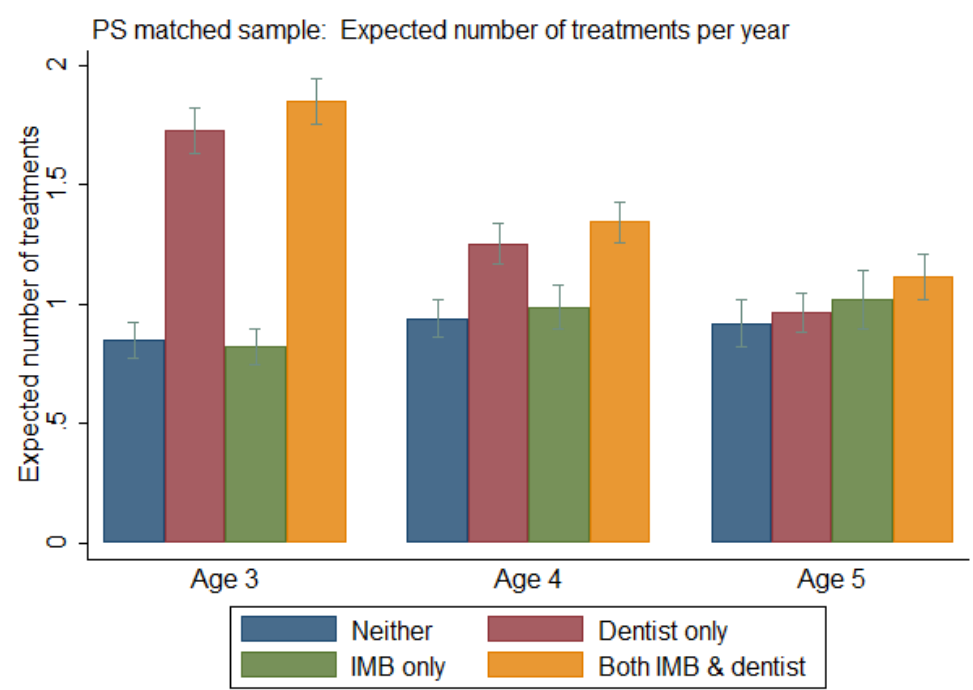


Figure 5.3. Predictions of annual payment from two-part model

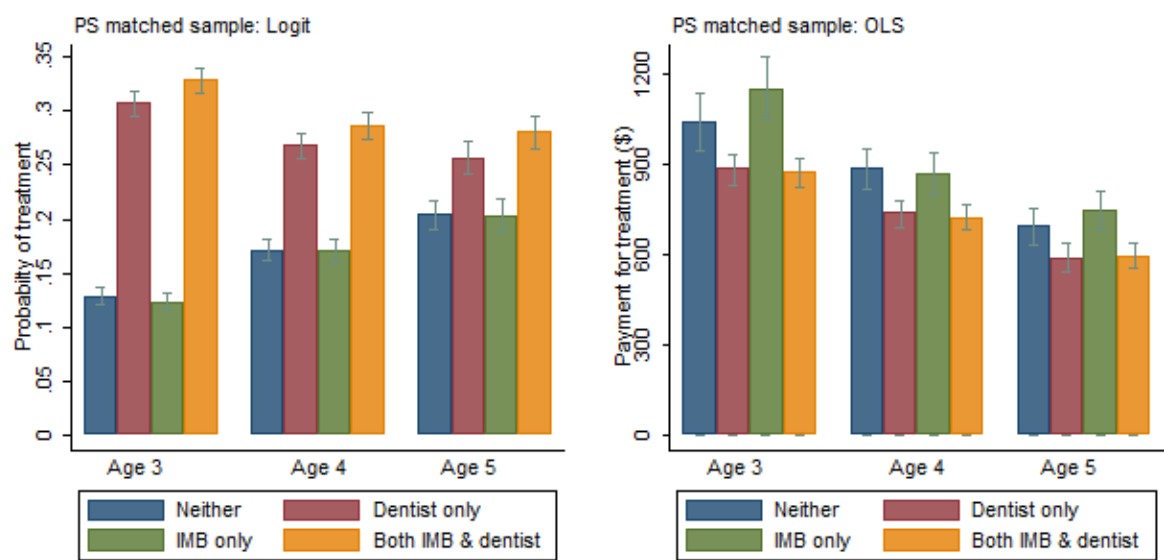
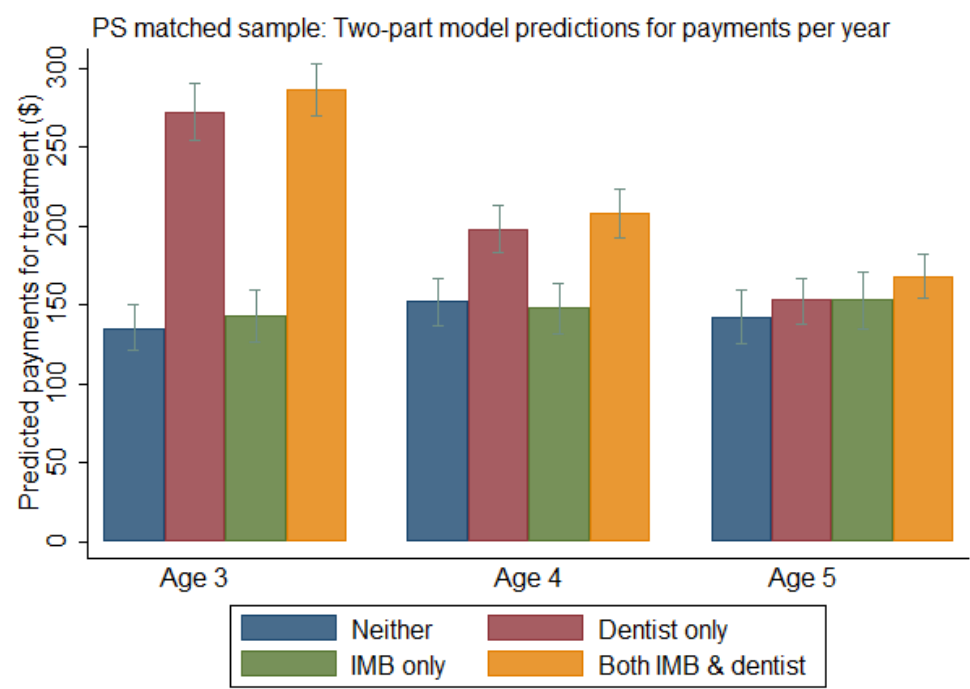


Figure 5.4. Predicted annual payment, combined results of two-part model



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6. Effect of the mode of delivery for preventive oral health services before 3 years of age on the dental caries experience of kindergarten children

6.1. Overview

Since 2000, North Carolina (NC) Medicaid has reimbursed preventive oral health services provided to young children in the medical office via the Into the Mouths of Babies (IMB) program. We compared the effect of receiving preventive oral health services before age three during only IMB visits, only dentist visits, both, or neither on caries experience and untreated caries among kindergarten children. This retrospective cohort study included children with 2005-2006 NC kindergarten oral health surveillance data, enrolled in Medicaid before age one, and still enrolled after their first birthday. A zero-inflated negative binomial regression and binomial logistic regression were used to estimate caries experience (defined as the number of decayed, missing and filled primary teeth (dmft)) and the proportion of untreated decayed teeth (d/dmft) at age five, respectively. Models adjusted for relevant child- and county-level characteristics and used propensity scores with inverse-probability-of-treatment-weights to address observed selection bias. The analytical sample included 29,173 children. Only 37% of children received preventive oral health services before age three; these children were more likely to have had IMB visits (80%) than dentist visits (20%). Children with multiple IMB visits or dentist visits had similar dmft scores at age five, but the proportion of untreated caries was higher among children who had only IMB visits. The similar caries experience of children having multiple IMB visits and dentist visits suggests that the setting and provider do not influence the effectiveness of preventive services.

Children who had only IMB visits before age three may encounter challenges to obtaining follow-up treatment for decay.

6.2. Introduction

Young children encounter difficulty accessing dental care, which contributes to increasing rates of early childhood caries (ECC) that disproportionately affect infants and toddlers living in poverty.¹ Recognizing that young children make more visits to medical offices than dental offices, many state Medicaid programs now reimburse primary care providers (PCPs) to deliver preventive oral health services.² Since 2000, North Carolina (NC) Medicaid's "Into the Mouths of Babes" (IMB) program has trained pediatric and family medicine PCPs to provide preventive oral health services to young children less than three years of age. Similar to preventive services received in a dental office for young children, IMB visits include oral health counseling for parents, application of fluoride varnish to prevent ECC, and an oral evaluation and risk assessment with referral to a dentist if needed.³ IMB and similar programs in other states have helped increase access to oral health services and reduce treatments for young children enrolled in Medicaid.⁴⁻⁶ Overall, the percent of Medicaid children younger than five years old obtaining oral health services in NC increased from 17% in 2002 to 59% in 2011.⁷

Although the benefits of IMB visits are well-documented, less is known about what happens to the oral health of these children after three years of age, when they are no longer eligible to receive preventive oral health services from PCPs. Children having four or more IMB visits (compared to zero IMB visits) between 2000 and 2006 received fewer caries-related treatments after their IMB eligibility expired (ages 40-72 months).⁵ While this finding suggests IMB visits may be associated with better oral health, the study did not control for

preventive services received from dentists or examine the program's effect on clinical disease, which provides a better measure of access to care and overall oral health. Some barriers to dental care for children may ease as they age because dentists are more willing to care for older children⁸; however, workforce shortages and dentists' low rate of participation in Medicaid remain as barriers to dental care when children age out of the IMB program.

Widespread support exists for the integration of dentistry and medicine to promote young children's oral health⁹⁻¹², yet to date, no study has directly examined the oral health outcomes of children receiving preventive oral health services from PCPs compared to dentists, the conventional provider of these services. This comparison is important because more than 40 states have Medicaid programs that reimburse PCPs for applying fluoride varnish.² Using caries surveillance data and Medicaid claims, we compared the effect of receiving preventive oral health services before age three during IMB visits, dentist visits, both IMB and dentist visits, or neither on caries experience and the proportion of untreated decayed teeth among kindergarten children enrolled in NC Medicaid.

6.3. Methods

6.3.1. Sample

This retrospective cohort study utilized NC oral health status surveillance data and Medicaid files to examine children enrolled in kindergarten during 2005-2006. Public health dental hygienists conduct annual standardized open mouth screenings, providing information about dental disease levels, treatment needs, and presence of sealants in children in kindergarten and fifth grade.^{13,14} Data were available for 92,127 kindergarten children, which includes 82% of the state's public school kindergarten enrollment from 98 of 100 NC counties.¹⁵ Medicaid enrollment and claims files from the NC Division of Medical

Assistance provided information about demographic characteristics, length of Medicaid enrollment, and whether the child had a visit including preventive oral health services with a dentist, PCP, both, or neither before their third birthday.

The surveillance data and Medicaid files were previously linked using Link King software, which utilizes probabilistic and deterministic methods to link individual records based on the child's name, date of birth, gender, race, and county of residence.¹⁶ Of the 92,127 children included in the kindergarten surveillance data, 34,743 were successfully matched to Medicaid claims of children enrolled before age one and still enrolled after their first birthday. Children were excluded from the analysis if they had a non-unique identification number (n=442), less than 12 months of continuous enrollment in NC Medicaid before 3 years old (n=3,095), IMB claims post-eligibility (n=82), or missing information on decayed, missing (molars only), and filled primary teeth (dmft) (n=1,951), resulting in a final sample size of 29,173 children. This study was approved by an Institutional Review Board.

6.3.2. Measures

We examined two primary outcomes. First, caries experience was measured, based on visual inspection, as the total number of dmft of children enrolled in kindergarten. Primary incisors are excluded from the count of missing teeth because they could be missing for non-carious reasons. Second, to better understand a child's access to dental treatment, we examined the proportion of a child's caries experience that was untreated at the examination, defined as the number of decayed teeth divided by the total dmft score among those with dmft>0.

Our main independent variable, mode of delivery for preventive oral health services before age three, was operationalized as a 4-category variable: IMB visits only, dentist visits only (reference group), IMB and dentist visits, or neither. We chose age three because during the study period Medicaid reimbursed PCPs for up to 6 IMB visits before age three. IMB visits were identified with paid claims filed by physicians for preventive oral health services. A visit in a dental office with preventive services, reimbursed by Medicaid up to twice annually after any tooth erupts, was defined as having paid claims for a comprehensive or periodic evaluation with fluoride. Current Dental Terminology codes used to identify visits with preventive oral health services are provided in Table 6.1. Some dental visits included caries-related treatment because we did not attempt to identify the purpose of the visit.

We included child- and county-level characteristics, measured at or before age three, as explanatory variables that may affect dental caries status:

- Child-level: sex, race (white, black, other), Hispanic ethnicity, total number of months enrolled in Medicaid, number of well-child visits, and indicators of special health care needs, receipt of caries-related treatment, and whether any preventive oral health services were received in a Federally Qualified Health Center (FQHC), health department, or rural health clinic.
- County-level: proportion of population with access to fluoridated public drinking water¹⁷, indicators of rural or urban status¹⁸, and the number of dentists, pediatricians and family practice physicians¹⁹, and Medicaid eligible children younger than 18 years per 10,000 population.²⁰

6.3.3. Propensity score estimation

Propensity scores with inverse-probability-of-treatment-weights (IPTW) were used to address selection bias that could arise because of systematic differences between children with and without dentist visits. We were concerned about selection bias associated with visits to dentists because it is unknown if these visits are due to existing disease or demand for preventive services. Propensity scores were estimated using logistic regression to predict the likelihood of having a dentist visit with preventive services before age three. We controlled for the aforementioned covariates, including squared terms of continuous variables; we excluded the variable indicating receipt of treatment before age three due to its relationship with the exposure variable. We calculated standardized weights for each child. This approach assigns greater weight on children who received a dentist visit before age 3, but have characteristics more similar to children who did not receive dentist visit before age 3 and vice-versa.²¹ IPTW adjustment provides greater precision than propensity score matching and estimates the average treatment effect.²² To ensure appropriate comparison groups, we excluded children without dentist visits with a propensity score higher than the maximum or lower than the minimum propensity score of children with dentist visits. We evaluated the balance of covariates by examining the distribution of propensity scores across the four groups and calculating standardized differences before and after weighting.²³

6.3.4. Analytical approach

A zero-inflated negative binomial regression model was used to compare the overall mean number of dmft at five years old for children according to use of the four modes of delivery for preventive oral health services. A binomial logistic regression for d/dmft (where d/dmft is the number of “events”/number of “trials”) was used to estimate the mean

proportion of decayed teeth untreated for children with some dmft utilizing each mode of delivery.²⁴ Huber-White empirical standard errors adjusted for intra-group correlation due to clustering of children within counties. Regression models controlled for the aforementioned covariates. Predicted outcomes for each mode of delivery were estimated using the full sample, with 95% confidence intervals generated using 1,000 bootstrap replications. We calculated the difference in covariate-adjusted mean outcomes (i.e., mean dmft or mean proportion of decayed teeth) for each mode of delivery by subtracting the expected outcome for an average child utilizing each mode of delivery from the expected outcome for a child receiving no preventive oral health services and also from the expected outcome for a child receiving preventive services during only dental visits. Differences in outcomes were examined using Wald tests and 95% confidence intervals. All tests were performed in Stata/IC 12 (Statacorp, College Station, TX) using a 0.05 significance level.

6.3.5. Subgroup analyses

To examine the effect of multiple visits for preventive oral health services, we restricted the sample to children having 2 or more IMB visits, 2 or more dentist visits, both IMB and dentist visits, and no preventive oral health services before age three. We conducted another analysis examining dmft scores for children having 4 or more IMB visits, which is approximately equivalent to 2 applications of fluoride varnish per year, an amount shown to be effective at reducing caries-related treatments.⁵ Few children received more than 2 dentist visits before age three, which precluded analysis of this group. Little variation in the proportion of untreated decayed teeth for children having 4 or more IMB visits and dmft>0 precluded analysis of this outcome in this subgroup.

6.4. Results

Before three years old, 37% of children received preventive oral health services (Table 6.2). Children receiving preventive oral health services were more likely to receive services during IMB visits (27%), than dentist visits (7%), or both (3%). Children who received preventive services during only IMB visits compared to only dentist visits, lived in counties with fewer dentists and more children enrolled in Medicaid. Among children receiving preventive oral health services from only dentists, 33% received dental caries-related treatment before age three.

6.4.1. Propensity score model

After estimating the likelihood of receiving a dentist visit with preventive oral health services before three years old, no children had propensity score values beyond the region of common support (i.e., having values outside the range of the other group). The distribution of propensity scores was more similar across the four modes of delivery following IPTW adjustment (Figure 6.1). IPW improved balance of covariates as evidenced by reductions in absolute standardized differences for all covariates (Figure 6.2).

6.4.2. Analytical results

Results from the full and IPTW adjusted samples were similar in magnitude and statistical significance. Results are presented from only the weighted. Children who received preventive services during only IMB visits had significantly lower mean dmft scores at age five than children who visited only dentists (Table 6.3), but similar mean dmft scores as children who did not receive preventive oral health services before age three (Figure 6.3).

About 48% of children had some dmft at age five (n=13,966). Among children with some dmft, the mean proportion of untreated decayed teeth was greatest for children who did

not receive preventive oral health services before age 3 and children who had only IMB visits before age 3 (Figure 6.4). When compared to children not receiving preventive oral health services before age three, children who had only dentist visits and children who had both IMB and dentist visits had a significantly lower mean proportion of decayed teeth (Table 6.3). The percentage of dmft that was untreated (decayed teeth) experienced by an average child who received preventive oral health services during only IMB visits was 19.6 percentage points greater than that of an average child who had received preventive oral health services during only dentist visits.

6.4.3. Subgroup analyses

About 37% of children had 2 or more IMB or dentist visits with preventive oral health services before age three (dentist only=480; IMB only=3,907; both=848; neither=18,280). Having 2 or more IMB visits before age three was associated with a mean dmft score similar to having 2 or more dentist visits (Figure 6.3), but a significantly greater mean proportion of decayed teeth (Figure 6.4). Compared to having 2 or more dentist visits before age three, having 4 or more IMB visits (n=503) was associated with a significantly lower mean dmft score (Figure 6.3).

6.5. Discussion

This retrospective cohort study compared the effect of four modes of delivery for preventive oral health services before age three (IMB, dentist, both, or neither) on dental caries experience and untreated decay among Medicaid-enrolled children in kindergarten. Most children did not receive preventive oral health services before age three; those who did were more likely to receive services during IMB visits than dentist visits. Although children who had IMB visits had a lower dmft score than children who had visited dentists in our

main analysis, this difference is likely because a higher percentage of children with IMB visits had multiple visits (49%) than children visiting only dentists before age three (24%). Children who had more than one IMB or dentist visit with preventive oral health services had similar dental caries experience in kindergarten, suggesting that the setting and provider do not influence the effectiveness of the preventive services provided in this study. Because children from low-income families are more likely to experience tooth decay and less likely to visit a dentist than children from higher-income families¹, Medicaid programs that reimburse services provided in medical offices increase access to prevention for children living in poverty and thus may help to lessen oral health disparities.

Whereas the overall dental caries status of children with repeat IMB visits resembles that of children visiting dentists, their rate of treatment in a dental office appears to more closely resemble children not receiving preventive oral health services before age three. The proportion of untreated decayed teeth for children with no visits or only IMB visits was greater than that of children visiting dentists before three years of age, suggesting that the treatment needs of these children are less likely to be met. One explanation for this finding is that these children had difficulty establishing a dental home.

Establishing a dental home is important for long-term oral health.²⁵ Preventive oral health services provided in the medical office to young children are not intended to replace regular dental visits in which potential problems can be monitored and treated, especially as children grow older. Rather, medical offices can provide access to preventive services at an age when many children find it most difficult to access care in dental offices. However, the transition from receiving care in a medical office to a dental office may affect continuity of oral health services because barriers to dental care remain highly prevalent. Although

referrals by PCPs increase young children's likelihood of having a dental visit, few children obtaining IMB services receive referrals.²⁶⁻²⁸ Among parents receiving referrals, only 41% reported receiving help scheduling a dental appointment.²⁹ Efforts to improve dental referrals are included in the development of risk assessment and referral tools that attempt to identify children at greatest risk of developing caries and prioritize referrals based on this risk.^{28,30,31} A study examining a risk assessment tool used by IMB providers reported that caries presence was the strongest predictor of dental referral.²⁸ Preliminary research suggests quality improvement activities utilizing risk assessment tools can increase referrals.³²

We found evidence of a threshold effect for the effectiveness of oral health services delivered in the medical office on dental caries experience. Less dental disease was experienced by children who had repeat IMB visits than children not receiving preventive oral health services before three years of age. This finding is consistent with a prior evaluation of the IMB program, which reported that having 4 or more visits before age three compared to none reduced caries-related treatments and hospitalizations.^{5,33} Evidence about the effectiveness of a single application of fluoride varnish in preventing caries in young children is mixed. While twice yearly applications of fluoride varnish has been shown to be effective in preventing caries in the primary and permanent dentitions of young children³⁴⁻³⁷, two randomized controlled trials reported a preventive effect of fluoride varnish after a single application.^{38,39} Our results suggest a preventive effect after multiple applications of fluoride varnish, which may be due in part to young children's ongoing tooth eruption.

This study has several limitations. Selection bias could exist if there are systematic differences between children utilizing different modes of delivery of preventive oral health services. Although IPTW adjustment attempts to address this bias, it cannot adjust for

unobserved differences between children and use of data collected largely for administrative purposes limits availability of variables. Additionally, although more than 40 state Medicaid programs reimburse PCPs for providing fluoride varnish, generalizability beyond NC may be limited.²

Only about one-third of children enrolled in NC Medicaid received preventive oral health services before age three; those who did were more likely to receive preventive oral health services during IMB visits than dentist visits. Children who had more than one IMB or dentist visit with preventive oral health services before age three had a comparable dental caries experience at age five; however, children who had only IMB visits had a significantly greater proportion of untreated decay. Caries experience was lessened by having multiple IMB visits before age three. Although medical offices can provide access to preventive services at an age when many children find it most difficult to access care in dental offices, establishing dental homes is important for long-term oral health.²⁵ Further research should examine strategies to increase utilization of preventive oral health services and to link medical and dental homes through effective referrals.

Table 6.1. Description of Current Dental Terminology (CDT) codes used to identify preventive oral health services received in dental and medical offices

Identifies visit setting:	CDT Code	Description
IMB & Dentist	D0150	Comprehensive oral evaluation
IMB & Dentist	D0120	Periodic oral examination
IMB & Dentist	D1203	Topical application of fluoride (Prophylaxis not included) for a child
IMB & Dentist	D1201	Prophylaxis application of fluoride for a child
IMB	D1330	Oral hygiene instructions for a child
IMB	W8002	Initial oral screening
IMB	W8003	Periodic oral screening

CDT codes changed from “W” to “D” during the study period, but represent the same services. NC Medicaid policy required physicians to provide all three services (evaluation, hygiene instructions, and fluoride application) during the visit, identified by paid J claims. Preventive visit in a dental office was defined as paid K claims for a comprehensive or periodic evaluation with fluoride.

Table 6.2. Baseline characteristics of NC Medicaid-enrollees entering kindergarten in 2005-2006 (n=29,173)

Variable description; mean (standard deviation)	All (n=29,173)	Modes of delivery for preventive oral health services before 3 years old			
		Neither (n=18,280)	Dentist visits only (n=2,042)	IMB visits only (n=8,003)	Both dentist & IMB visits (n=848)
Dependent variables					
Caries experience (dmft score)	2.2 (3.2)	2.1 (3.1)	3.4 (3.9)	2.0 (3.1)	3.0 (3.7)
Proportion of untreated decayed teeth	0.2 (0.4)	0.2 (0.4)	0.1 (0.3)	0.2 (0.4)	0.1 (0.3)
Explanatory variables					
<i>Child-level characteristics</i>					
Number of months enrolled in Medicaid	31.7 (3.9)	31.5 (4.3)	32.5 (2.3)	32.1 (3.2)	32.7 (1.9)
Race (%)					
White	41.3	42.5	34	40.7	36.4
Black	41.5	41.1	46	41.1	42.7
Hispanic ethnicity (%)	8.6	8.5	11.2	7.9	11.9
Male (%)	50.7	50.5	48	51.4	53.4
Special healthcare needs (%)	3.6	3.3	3.9	4.2	4.5
Number of well-child visits before 3 years of age	3.5 (2.0)	3.1 (2.0)	3.6 (2.2)	4.5 (1.6)	4.9 (1.6)
Any caries-related treatments before 3 years of age (%)	4.6	1.4	33.3	2	31
Any preventive oral health services received in FQHC (%)	18	10.9	28.7	29.1	42.2
<i>County-level characteristics</i>	4.6	1.4	33.3	2	31
Medicaid eligibles younger than 18 years per 10,000 population	469.1 (141.0)	462.4 (141.5)	432.3 (131.8)	496.4 (139.6)	452.8 (124.4)
Primary care providers per 10,000 population	4.2 (2.0)	4.2 (2.0)	4.4 (2.1)	4.2 (1.8)	4.1 (2.0)
Dentists per 10,000 population	3.8 (1.8)	3.9 (1.8)	4.4 (1.9)	3.5 (1.5)	3.8 (1.7)

Explanatory variables not presented in this table include the rural/urban status of the child's county of residence and the percent of the county population with fluoridated drinking water. dmft – decayed, missing, and filled primary teeth; FQHC - Federally Qualified Health Center.

Table 6.3. Adjusted differences in predicted dmft score and proportion untreated decay at 5 years old compared to child with only dental visits before 3 years of age

	Difference in mean dmft score (n=29,173)	Difference in mean proportion of untreated decay (n=13,966)
IMB only	-0.364** (-0.618, -0.110)	0.196** (0.143, 0.250)
Both	-0.101 (-0.488, 0.286)	0.044 (-0.055, 0.142)
None	-0.289* (-0.519, 0.059)	0.203** (0.155, 0.250)

95% confidence intervals located in parentheses. *p < 0.05, **p < 0.01.

Results are for propensity score weighted sample and include children with any number of visits for preventive oral health services.

Models control for explanatory variables listed in Table 6.2.

Figure 6.1. Distribution of cohorts, pre- and post-adjustment using inverse-probability-of-treatment-weights

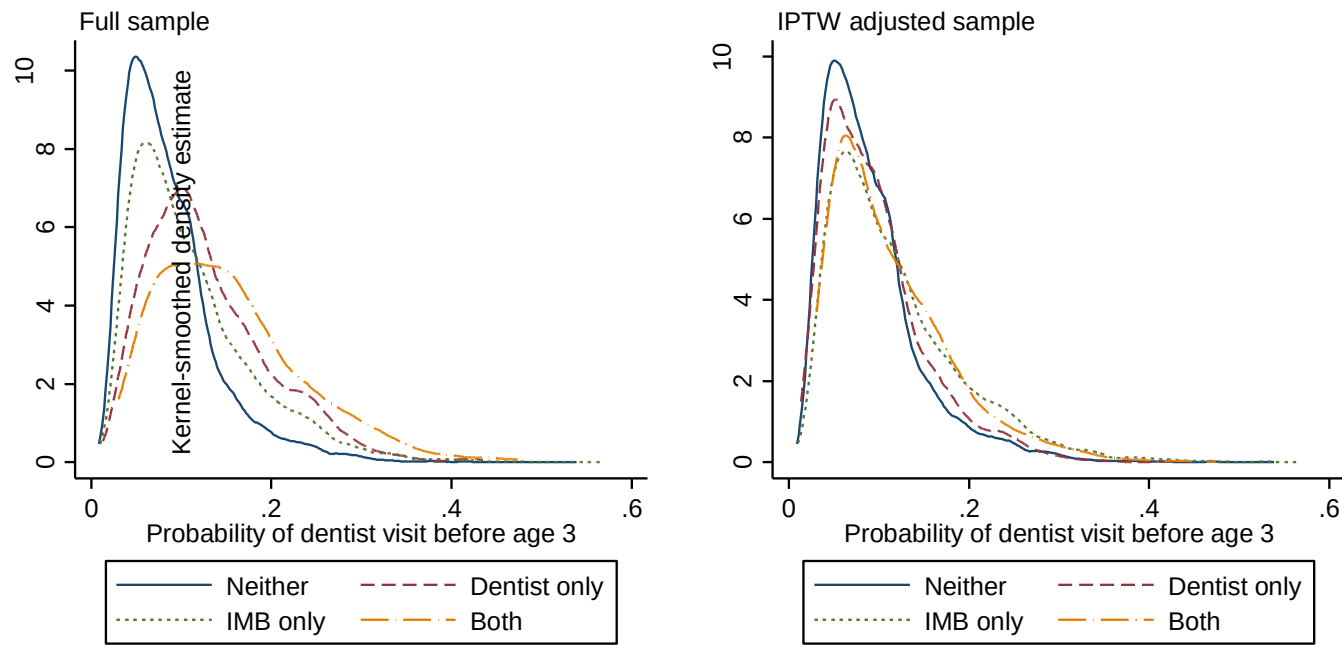


Figure 6.2. Difference in absolute standardized differences for covariates in the unadjusted and weighted samples

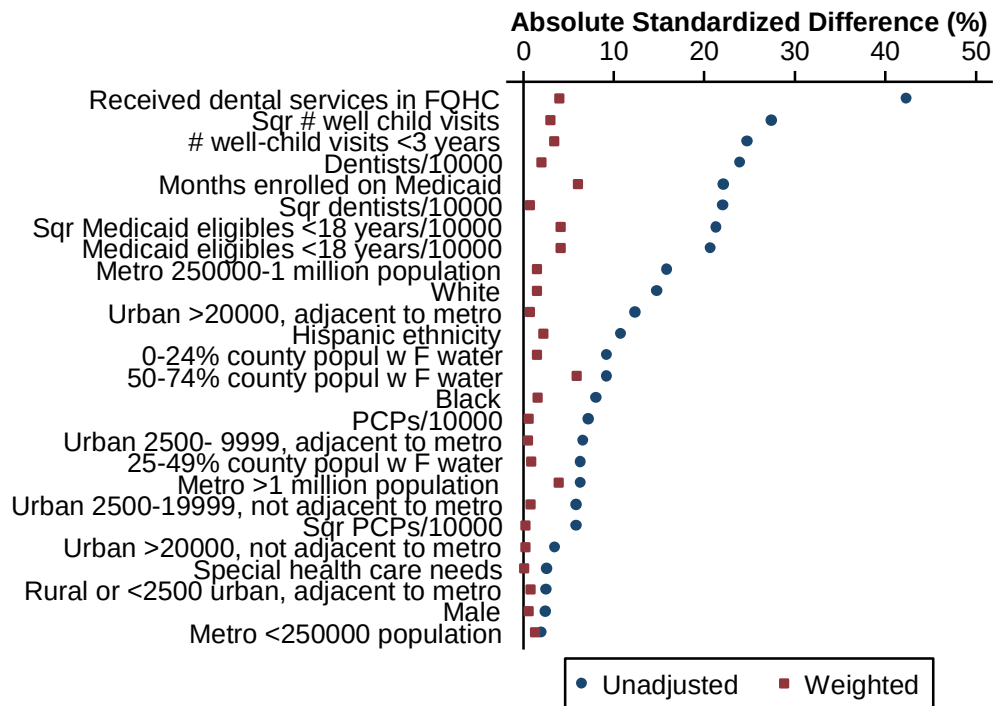


Figure 6.3. Adjusted mean dmft score per child among NC Medicaid-enrollees at 5 years old age, by mode of delivery and analytic sample

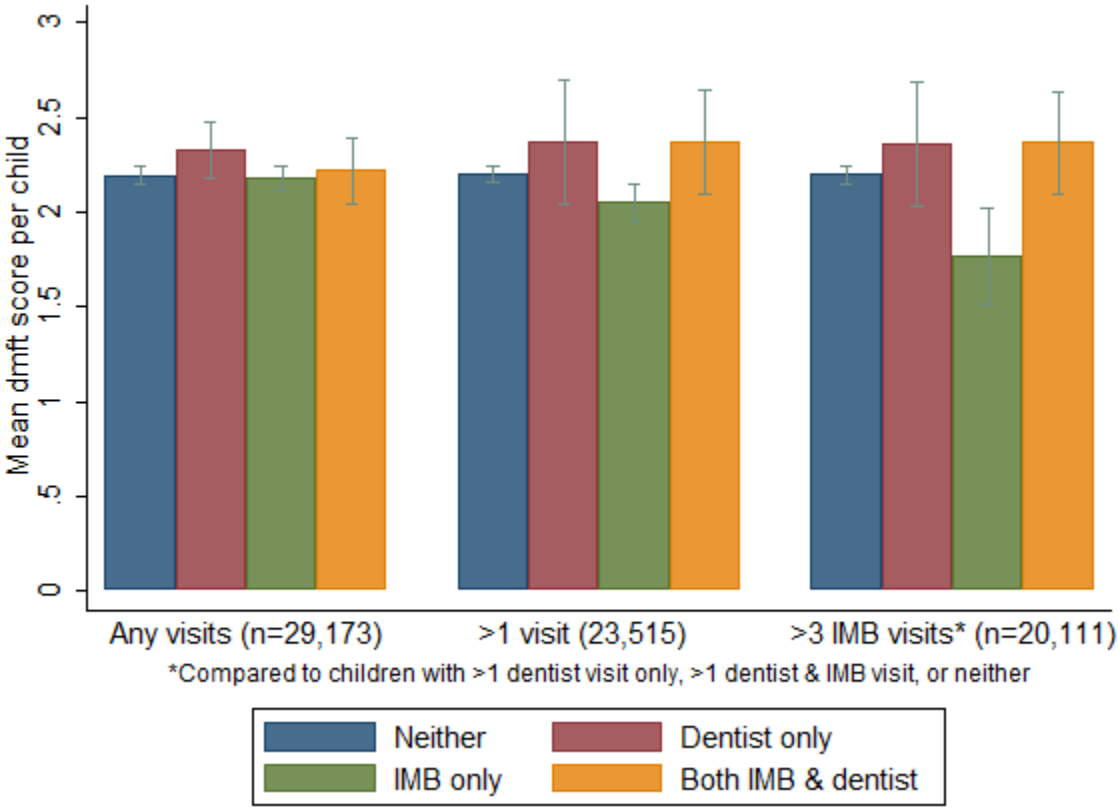
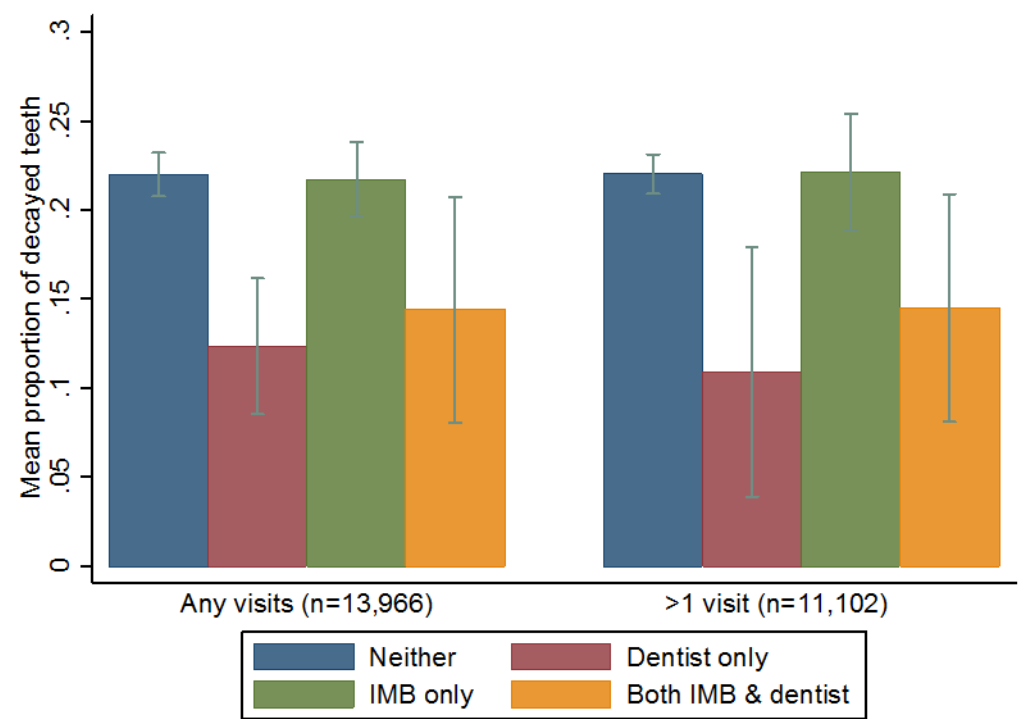


Figure 6.4. Adjusted mean proportion of untreated decayed teeth per child among NC Medicaid-enrollees at 5 years of age with dmft>0, by mode of delivery and analytic sample



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7. Discussion

Young children encounter challenges to obtaining dental care, which contributes to increasing rates of ECC that disproportionately affect infants and toddlers living in poverty.¹ Recognizing that young children make more visits to medical offices than dentist offices, most state Medicaid programs now reimburse PCPs to deliver preventive oral health services.² Since 2000, NC Medicaid's IMB program has trained pediatric and family medicine PCPs to provide preventive oral health services to young children less than 3 years of age.

Although the benefits of IMB visits are well-documented, less is known about what happens to the oral health of these children after three years of age, when they are no longer eligible to receive IMB services. Children who received 4 or more IMB visits compared to 0 IMB visits had a lower likelihood of receiving CRT in both hospital and office settings and a 17% reduction in CRT up to 6 years of age.^{3,4} Additionally, having 4 or more IMB visits was associated with lower Medicaid payments for hospital or dentist office treatments, suggesting fewer treatments within a treatment episode.³ While these findings suggest IMB visits promote oral health, these studies did not control for preventive services received from dentists or examine whether IMB visits promote oral health as well as visits to dentists, the traditional provider of these services. Some barriers to dental care for children may ease as they age because dentists are more willing to care for older children;⁵ however, workforce shortages and dentists' low rate of participation in Medicaid are likely to remain as barriers to dental care.

Widespread support exists for the integration of dentistry and medicine to promote young children's oral health, yet to date, no study has directly examined the oral health-related outcomes of children receiving preventive oral health services during IMB visits compared to visits to dentists.⁶⁻⁹ This dissertation examined the comparative effectiveness of medical and dental modes of delivery for promoting the oral health of young children less than 3 years of age. To understand how the provider of preventive oral health services may affect subsequent oral health-related outcomes, we examined the following outcomes occurring after a child's third birthday: (1) time to a dentist visit; (2) receipt of CRT and payment for CRT; (3) and the number of decayed, missing, and filled teeth (dmft) and proportion of untreated decayed teeth. All studies used NC Medicaid claims. The third study used a combination of claims data and oral health surveillance data. This concluding chapter summarizes the main findings from the three studies, discusses limitations of each study, and describes policy implications and recommendations for future research.

7.1. Study 1: Effect of the mode of delivery for preventive oral health services before 3 years of age on the time to a dentist visit after a child's third birthday

Preventive oral health services provided by PCPs in the medical office help to improve young children's access to care. Because most state Medicaid programs limit these benefits to children younger than 4 years of age, we examined continuity of dental care for children aging out of the IMB program. We compared the time to a dentist visit for 95,578 children enrolled in NC Medicaid during 2000 to 2006 who had only IMB visits, only dentist visits, or both IMB and dentist visits before 3 years of age. Children who had only dentist visits or both dentist and IMB visits before age 3 experienced a similar time to a dentist visit after their third birthday. Compared to children who had only dentist visits before age 3,

children who had only IMB visits experienced a longer time to a dentist visit after their third birthday. Because referrals increase young children's likelihood of having a dental visit, medical offices providing IMB services may need to be more attentive to referrals, particularly when children get near the end of their eligibility for IMB services.¹⁰⁻¹²

Additionally, we found that increasing the number of dentists per county slightly increased the hazard of a dentist visit for children having only IMB visits, suggesting lack of available dentists may help to explain the difference in the time to a dentist visit for children. To promote continuity of dental care for children as they age and to increase the time available for transition from medical to dentist offices, state Medicaid programs may want to consider increasing the upper age limit for reimbursement of preventive oral health services provided in the medical office, a strategy that may be particularly helpful in communities with few available dentists. Additionally, increasing the number of available dentists and mid-level dental providers may help to alleviate barriers to dental care.^{13,14} While dentist visits are important for monitoring potential problems and providing treatment, expanding the number providers delivering oral health services may help to increase access to care.

7.2. Study 2: Effect of different modes of delivery on caries-related treatments and associated payments during ages 3 to 5 years

To understand how the provider of preventive oral health services may affect subsequent rates of CRT and associated payments, we compared 159,422 children enrolled in NC Medicaid during 2000-2006 who received preventive oral health services during only IMB visits, only dentist visits, both IMB and dentist visits, and neither before 3 years of age. Most children did not receive preventive oral health services before 3 years of age; those who did were more likely to receive it during IMB visits. Findings from this study indicate that

the provision of preventive oral health services in the medical office through the IMB program helped to increase the number of children receiving prevention before 3 years of age.

Additionally, compared to children who received preventive services before age 3 from only dentists, children who had only IMB visits had on average fewer dental CRT and had lower payments for CRT on average during ages 3 to 5 years, suggesting that IMB services may prevent dental caries. However, this observational study may suffer from selection bias if there are unobserved factors affecting the provider of children's preventive oral health services. For example, the IMB program may be associated with fewer CRT and lower payments than dentist visits if children who had only IMB visits before 3 years of age were at low-risk of developing ECC and thus waited to visit a dentist. Lacking clinical outcome measures, we cannot conclude if children who received only IMB visits had fewer CRT and lower payments due to improved oral health or poor access to dental treatment.

7.3. Study 3: Effect of the mode of delivery for preventive oral health services before 3 years of age on the dental caries experience of kindergarten children

This retrospective cohort study used NC Medicaid claims (2000-2006) linked to NC oral health surveillance data (2005-2006) to examine the dental caries experience of 29,173 children enrolled in kindergarten. As observed in study 2, children who obtained preventive oral health services before age 3 were more likely to receive them during IMB visits than dentist visits. Although children who had only IMB visits before age 3 had had a lower dmft score than children visiting dentists in our main analysis, this difference is likely because a higher percentage of children visiting PCPs had multiple visits (49%) than children visiting only dentists before age three (24%). Children having 2 or more IMB or dentist visits with

preventive oral health services had a similar mean number of dmft, suggesting that the provider does not influence the effectiveness of the preventive services provided in this study.

Children who had only IMB visits had a greater proportion of untreated decayed teeth than children who received preventive oral health services from dentists before age 3. This finding suggests that the treatment needs of these children are less likely to be met. One explanation for this finding is that these children had difficulty establishing a dental home. Although referrals by PCPs increase young children's likelihood of having a dental visit, few children obtaining IMB services receive referrals.¹⁰⁻¹² Preliminary research suggests quality improvement activities utilizing risk assessment tools can increase referrals.¹⁵ Although medical offices can provide access to preventive services at an age when many children find it most difficult to access care in dental offices, establishing dental homes is important for long-term oral health.

7.4. Limitations

This dissertation study has several limitations. First, all studies were observational and may suffer from selection bias if there are unobserved factors affecting children's receipt of preventive oral health services from a particular medical or dental mode of delivery. We were concerned that children's unobserved risk of dental caries might affect the provider of preventive oral health services before 3 years of age. Specifically, we were concerned about bias due to differences between children with and without dentist visits because it is unknown if these visits are for existing disease or demand for preventive services. We attempted to adjust for selection bias by using propensity scores, however, this method does not adjust for unobserved differences between children. We supplemented our data with

publically available county-level measures relevant to this analysis, however, additional information about children, such as brushing practices and dietary habits, would help us to better understand utilization decisions and treatment outcomes. Because we lack sufficient data on children's risk of dental caries, the results of this study may be influenced by selection bias.

In study two, we used propensity score matching to obtain a sample of children with balanced covariates across the four groups identifying the mode of delivery for preventive oral health services. This sample included about 15.5% of our full sample and therefore may not be representative of the population of young children enrolled in NC Medicaid. Compared to the matched sample, children in the full sample had on average fewer well-child visits, were less likely to receive oral health services in a public health center, and had a greater likelihood of having a dentist visit with preventive oral health services before age 3. Because the matched sample was limited to children who differed, based on observed covariates, only on the provider of preventive oral health services before 3 years old, we were able to estimate an unbiased treatment effect. Moreover, results from the full and matched samples were similar in magnitude and significance.

Because the IMB program began in 2000, this analysis includes the period of time when IMB was being implemented. During implementation, children did not have the opportunity to receive the recommended 6 IMB visits because of their age at implementation and because fewer PCPs were trained to provide services. Despite this limitation, we observed that the IMB program improved access to preventive oral health services and that children who had only IMB visits had dmft scores similar to children who had only dentist visits before age 3. Since 2000, the number of PCPs providing IMB services and number of

IMB visits has increased.¹⁶ As more children receive preventive oral health services early in life before ECC begins and during more visits, the preventive effect of the IMB program may become more pronounced. Additional research is needed to examine the effect of the current, widely implemented IMB program.

Finally, findings from all three studies may have limited generalizability because the data was collected in NC and represents a Medicaid population. However, more than 40 state Medicaid programs reimburse fluoride varnish delivered in medical offices.² Thus, these findings are pertinent for low-income children throughout the country and have the potential to lessen oral health disparities among children.

7.5. Policy implications and future research

State Medicaid programs have sought to improve young children's access to preventive oral health services by reimbursing PCPs for applying fluoride varnish in the medical office. The NC Medicaid IMB program has supported nearly one million visits since implementation in 2000, providing sufficient data to conduct comparative effectiveness research to understand how the oral health-related outcomes may differ for young children who received preventive oral health services during only IMB visits, only dentist visits, both IMB and dentist visits, and neither before 3 years of age.¹⁶

Collectively, the findings from these studies suggest that the provision of preventive oral health services to young children during IMB visits in medical offices prevents dental caries as well, if not better than the provision of preventive dental services by only dentists. Children with only IMB visits before age 3 had fewer dental CRT and lower CRT payments during ages 3 to 5 years than children who received preventive services from only dentists before age 3. Moreover, the results of study 3, which used clinical measures of oral health

status, indicated that children who had 2 or more IMB or dentist visits with preventive services before age 3 had a similar number of dmft during kindergarten. Medical offices can provide access to preventive services at an age when many children find it most difficult to access care in dental offices. This is an important finding as young children are likely to face increasing difficulty in accessing dentists as more children become eligible for dental services through enrollment in Medicaid, which is expected to be facilitated by the Affordable Care Act.¹⁷

Additionally, the IMB program provides additional opportunities for children to receive applications of fluoride varnish. Multiple applications of fluoride varnish have been found to be effective in preventing caries, in particular when applied as new teeth emerge.^{4,18-}

²⁰ While Medicaid reimburses preventive visits in a dentist office up to twice per year, IMB services are currently reimbursed up to 6 times before 36 months of age. When examining the full sample of kindergarten children, we observed that children who had only IMB visits had a lower dmft score than children visiting dentists, which is likely because a higher percentage of children with IMB visits had multiple visits (49%) than children visiting only dentists before age three (24%). Because children from low-income families are more likely to experience tooth decay and less likely to visit a dentist than children from higher-income families, Medicaid programs that reimburse services provided in medical offices can increase access to prevention for children living in poverty and thus may help to lessen oral health disparities. Although most state Medicaid program reimburse PCPs for providing fluoride varnish to young children, there exists much variation across states in terms of services provided, reimbursement rate, and provider participation. Results from this study support the dissemination of this innovative model developed in NC that includes oral health counseling

for parents, an open-mouth evaluation, and application of fluoride varnish.

Despite the benefit of IMB services, children having only IMB visits before their third birthday continue to encounter barriers to dentist visits as they age. This conclusion is supported by findings from study 1 and 3, respectively, as children who had only IMB visits experienced a longer time a dentist visit following their third birthday and had a higher proportion of untreated decayed teeth in kindergarten than children who visited dentists before age 3. To improve access to care in dental offices, medical offices providing IMB services may need to be more attentive to referrals, particularly when children get near the end of their eligibility for IMB services. Referrals from physicians increase young children's likelihood of having a dental visit.¹⁰⁻¹² However, few children obtaining IMB services receive referrals, and fewer than half of parents received help scheduling the dentist visit.^{11,21} Children who had both IMB and dentist visits before age 3 were more similar to children who only had dentist visits for all oral health-related outcomes examined. This subgroup of children receiving IMB services was more likely to be able to successfully transition to a dental home following the end of their eligibility for the IMB program. Although our administrative data cannot identify which children received referrals, nearly all of these children had an IMB visit before their first dentist visit.

Improving referrals may not be sufficient if there are not dentists available to see these children. Results of study 1 suggest that having more dentists in a county was associated with a slightly higher hazard of a dentist visit after age 3 for children having only IMB visits. To promote continuity of dental care for children as they age and to increase the time available for transition from medical to dentist offices, state Medicaid programs may want to consider increasing the upper age limit for reimbursement of preventive oral health

services provided in the medical office. This strategy may increase access to care and promote the oral health of children living in communities with few available dentists. Currently, 11 state Medicaid programs reimburse the application of fluoride varnish in medical offices for children aged 6 years and older.² Additionally, increasing the number of dentists and mid-level dental providers who see children may help to alleviate barriers to dental treatment.^{13,14} Beyond increasing the number of providers, work is needed to encourage the existing dental workforce to see more young Medicaid-enrollees. While dentist visits are important for monitoring potential problems and providing treatment, expanding the number and type of providers delivering oral health services may help to increase access to care for young children. Further research is needed to examine strategies to increase utilization of preventive oral health services, improve access to dental treatment, and to link medical and dental homes through effective referrals.

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