REFERRALS FOR DENTAL CARE IN A MEDICAL OFFICE-BASED PREVENTIVE DENTAL PROGRAM

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ABSTRACT

BHAVNA T. PAHEL: Referrals for Dental Care in a Medical Office-based Preventive Dental Program
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Preschool age children from low-income families in North Carolina are experiencing an increase in tooth decay and have poor dental care access. In response, the NC Medicaid program began reimbursing primary care medical practitioners to provide preventive oral health services as part of an innovative program known as Into the Mouths of Babes (IMB). Since 2000, IMB participating providers are reimbursed for providing: 1. oral health screening, risk assessment and needed referrals to dentists; 2. parent counseling about infant oral health; and 3. topical fluoride therapy for the child's teeth. The three studies in this dissertation examined the risk assessment and referral component of IMB.

The first and second studies assess the predictors and effectiveness of physicians' referral recommendations. They use a dataset (2000-02) that combines Medicaid claims for IMB, and medical and dental visits with physician-completed child oral health risk assessment forms that contain information on child oral health status. The third study is an intent-to-treat analysis that compares time to use of dental care for children receiving well-child care in practices participating in IMB compared to non-participating practices. The data for this study are Medicaid claims from 2004-2006. Results from the first two studies indicate that physician referrals facilitate use of dental care by children receiving the referrals. However, physicians tend to under-refer and their referrals result in dental visits

for only a small proportion of children who need dental care. We conclude that increased emphasis is needed on training pediatric primary care providers to identify children most in need of dental care and in developing systems and processes that are likely to enable providers to help children in gaining access to needed dental services. The third study provides initial evidence that practice participation in IMB reduces dental visit rates for children seen for well-child care in IMB practices compared to practices that never participated in IMB. The conclusion is that we were better able to detect the effect of oral preventive services provided as part of IMB than any effect from the dental screening services, which needs further study.

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PREFACE

This dissertation is organized in a non-traditional format. The first chapter provides an introduction to the aims of the dissertation and a brief overview of the conceptual framework and a statement of the significance of the work. Chapter 2 provides the background, literature review and conceptual framework for the dissertation. Chapter 3 describes the methodology used to address the three research questions in this dissertation and includes a description of data linkages carried out for constructing the analytic files. Chapters 4, 5 and 6 are manuscripts for the three studies in this dissertation. These three chapters must stand alone as manuscripts to be submitted for publication and likely have some redundancies with the earlier chapters. Chapter 7 presents a synthesis of the findings, policy implications, strengths and limitations of the three studies and provides directions for future research. The dissertation also includes two appendices. Appendix A includes a technical report that describes the process of imputing missing dental caries data, the main explanatory variable in the first study. Appendix B includes a manuscript that provides a description of the process of linkage of two data sources (NC Medicaid claims and physician-completed child oral health risk assessment records) used for the first two studies.

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LIST OF ABBREVIATIONS

AAP – American Academy of Pediatrics

AAPD – American Academy of Pediatric Dentistry

CDC – Centers for Disease Control and Prevention

ECC – Early Childhood Caries

EFs – Encounter Forms

IMB – Into the Mouths of Babes

NC – North Carolina

WCV – Well child visit

1. INTRODUCTION

1.1. Background

The increasing prevalence of tooth decay among children less than 5 years of age (Early Childhood Caries, ECC), particularly those from low-income families, is a matter of great concern among many quarters [1]. Not only do children from low-income families bear a disproportionate burden of this disease, they also experience the poorest access to dental care and the lowest rates of dental care utilization of all socioeconomic groups [2]. These factors led a previous U.S. Surgeon General, Dr. David Satcher, to refer to ECC as a silent epidemic in the United States [3].

Numerous factors prevent preschool aged children from obtaining the care they need. These factors include: lack of awareness among parents of young children about the importance of primary teeth, lack of training of general dentists in providing care to infants and toddlers, a shortage of pediatric dentists in the United States and many general dentists' unwillingness to see low-income children with public insurance coverage because of poor reimbursement for dental care offered by such programs compared to private insurance [2, 4, 5].

Parents of young, low-income children are unlikely to seek dental care for their child, but frequently visit a primary care physician or pediatrician for sick- and well-childcare during the early childhood years. Consequently, the pediatric primary care setting recently has gained attention as a possible venue for providing preventive dental services to preschool aged children. This idea is supported by professional guidelines, which recommend that physicians should screen children for dental disease during routine medical visits and provide referrals to the dentist if needed [6, 7]. These screenings are important, particularly for low-income, pre-school aged children because they can aid in early detection of ECC or identify those at elevated risk for ECC and possibly interrupt the trajectory of the disease. Most physicians self-report in national surveys that they are likely to conduct screenings for dental risk factors and obvious dental disease [8, 9]. Studies also suggest that they can recognize obvious disease with a reasonable degree of accuracy [10]. Yet many physicians report difficulty in making referrals because of a limited supply of dentists [9].

Beyond these initial evaluations, we know little about factors that determine if referrals are made or not, or if subsequent visits to dentists actually take place as a result of physicians' referrals for dental care. These questions have taken on increasing importance because of severe limitations in access to dental care for low-income children enrolled in public insurance programs and because of a number of recently implemented programs that encourage non-dental health care professionals to provide preventive dental services for young children [11].

This dissertation evaluates the screening, risk assessment and referral components of "Into the Mouths of Babes" (IMB), a comprehensive preventive dental program being offered in medical offices across North Carolina for Medicaid-enrolled children birth through 35 months of age. The purpose of this dissertation is to determine the effects of IMB screening and risk assessment on physician referrals for dental care and subsequent visits for dental care. This analysis of referrals is based on the premise that the increased attention to dental health by physicians may lead to more timely referrals for treatment of existing disease. Further, if physician referrals are effective, more children may have the opportunity to establish a usual source of dental care, i.e., a dental home, early in life.

1.2. Conceptual framework

The conceptual framework that guides this dissertation draws upon two sources. The study broadly falls within a risk-based approach to physician referrals for dental care proposed by the U.S. Preventive Services Task Force [12]. This approach, based on a systematic review of the literature on physicians' role in preventing ECC, calls for a risk-based triaging of children through the primary care medical office into the dental setting. This approach also is consistent with physician guidelines from the American Academy of Pediatrics [6] and the National Maternal and Child Health Bureau [7] that recommend that all children should receive an oral health risk assessment by their physician as part of their routine medical visit. The AAP guidelines further emphasize that children identified as having ECC or those considered to be at elevated risk should be referred to the dentist. Although some children are expected to make a dental visit irrespective of their risk and referral status, the framework suggests that a physician referral is likely to facilitate use of dental care for those with ECC or elevated risk.

Further, in examining the predictors of physician referrals for dental care we draw upon Shortell's model of physician referral behavior [13]. This model provides a comprehensive list of factors including patient, physician and community-level characteristics that are likely to influence the process of referrals. The literature review and discussion of the conceptual framework in chapter two provide more detailed information about the risk-based approach to physician referrals and the factors that influence this process. It also includes a discussion of Shortell's model and its relevance to the research questions in this dissertation.

1.3. Specific Aims

This dissertation includes three studies which concentrate first on referral practices (Study 1) and their results among those who received a referral (Study 2) using records completed by participating physicians and Medicaid claims. The third study is a hypothesis-testing analysis of the effect of practice-level participation in IMB on children's access to dental care (Study 3).

The aims for the three studies are as follows:

AIM 1. To determine the appropriateness and predictors of referral for dental care for children who received dental screening and risk assessment services as part of an IMB visit.

a. Descriptive analyses were conducted to assess the appropriateness of physician referrals for dental care for children who received IMB services. Appropriateness was assessed in terms of the number of children with physician-identified ECC who received a referral to a dentist.

b. Regression techniques for hierarchical data were used to determine the predictors of physician referrals for dental care among children who received IMB screening and risk assessment services. The regression models estimated the separate effects of child- and medical practice-level variables on child-level referral rates.

AIM 2. To determine the effectiveness of a physician referral in promoting dental utilization among children who received IMB screening and risk assessment services.

The effectiveness of a dental referral by physicians participating in IMB in promoting dental use among children who received a referral was assessed using survival analysis techniques. The dependent variable for this model was the length of time it took for a child to visit a dentist subsequent to a physician referral as a function of child, medical practice and county characteristics.

AIM 3. To compare the time to use of dental care among children in medical practices participating in IMB with children from practices not participating in IMB.

This intent-to-treat analysis assessed the overall effectiveness of IMB in promoting access to dental care. Survival analysis techniques were used to determine whether children who had their first well-child visit in a practice participating in IMB had a shorter time to dental use than children from medical practices not participating in IMB.

1.4. Summary of significance

ECC is very prevalent among low-income and minority children in the U.S. and results in significant costs to the healthcare delivery system and society. Innovative programs that use pediatric healthcare settings for delivering preventive dental care are being explored to reduce their burden of disease. These programs also can improve access to dental care and reduce disparities in ECC. Many states reimburse non-dental healthcare professionals for providing preventive dental care in their offices. However, little empirical evidence is available about the effectiveness of physician-delivered services, including referrals and resultant visits to dental offices. This dissertation addresses this gap by analyzing the effects of a medical office-based preventive dental program that includes dental risk assessments and dental screenings on referrals for and use of dental care for preschool age, Medicaid-enrolled children in North Carolina. Information about physician referrals for dental care and the effectiveness of referrals in promoting use of dental care should aid policy makers, health professionals and researchers as they seek to develop strategies to reduce the burden of dental disease among low-income underserved children.

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2. LITERATURE REVIEW

2.1. Background

The prevalence of dental caries among preschool age children, referred to as Early childhood caries (ECC), is on the rise in the United States [1]. ECC disproportionately affects children from low-income families who often lack the resources to interrupt the trajectory of disease and it has tangible negative health effects that prevent children from achieving optimal health and development [2]. Although numerous models have been tested to reduce the burden of ECC [3], its rising prevalence and continuing disparities suggest that much more needs to be done to address this crisis in children's oral health. Programs that encourage pediatric primary care providers to deliver preventive dental services for infants and toddlers are a recent innovation in this area. Such programs hold promise in reducing the ECC burden because they usually are offered in conjunction with well-child visits, which start early and occur at regularly scheduled intervals, unlike dental visits in this population. Further, the use of the medical setting provides an opportunity to remove the artificial boundaries that separate the medical and dental care systems and create a more integrated system for caring for young children's oral health [4].

Because, medical office-based preventive dental programs are a recent innovation, there is limited evidence for their effectiveness. Apart from their long-term goal of preventing ECC, many of these programs also stress the importance of oral health risk assessment and referrals to dentists for children with ECC or those considered to be at elevated risk as a way of addressing children's more immediate dental needs. However, there is little evidence for factors that determine if physicians will make a referral or whether these referrals can facilitate access to and use of dental care by children receiving the referrals. This dissertation offers an opportunity to examine these issues in the context of North Carolina's Medicaid program, which started reimbursing medical providers in 2000 for conducting dental screenings, oral health risk assessment and referrals (as needed), parent oral health counseling and topical fluoride therapy for the child [5]. The three studies included in this dissertation focus on the dental screening, oral health risk assessment and referral component of this program. As such, they provide a unique opportunity to further our understanding of the role that physicians can play in facilitating the use of dental care for children in need of dental services.

2.2. Tooth decay among preschool children – etiology, prevalence, and outcomes

Early childhood caries (ECC) is the term used to describe tooth decay among children 5 years of age and younger. A diagnosis of ECC is made based on the presence of one or more decayed (cavitated or non-cavitated lesions), missing (because of dental disease), or filled tooth surface/s in any primary tooth in a child 71 months of age or younger [6]. ECC is a multicausal, infectious and transmissible disease [7-9]. The development of ECC is significantly modified by diet-related factors such as frequent consumption of sugars and multiple behavioral factors (e.g., poor oral hygiene and home dental care, poor maternal oral health, high sugar intake and improper bottle feeding practices like putting the child to bed with a bottle containing sugary liquids) [10, 11]. Evidence also points to household and neighborhood factors as social determinants of ECC [10]. For example, Willems and colleagues [12] found that children aged 24-35 months living in deprived neighborhoods and those belonging to minority ethnic groups had higher prevalence rates for ECC than their counterparts.

Five times more common than asthma [13], ECC is the most common preventable chronic disease encountered among children of preschool age in the U.S. [14]. Further, a recent report by the Centers for Disease Control (CDC) indicates that there was an increase in dental caries prevalence in the primary dentition of children (ages 2 to 5 years) from 24.2% in 1988-1994 to 27.9% during 1999-2002 [1]. Low-income and minority children bear a major burden of the disease [15-18]. The trend for dental caries in the primary dentition for years 2001-2004 indicates that children from families living below 100% of the federal poverty threshold were twice as likely to have untreated dental caries as their non-poor counterparts (children from families living at > 200% of the federal poverty threshold) [19].

Preschool-aged children from low-income families experience five times more untreated decay than their high income counterparts [17, 18]. For example, one study reports an ECC prevalence of 90% among 3-to-5 year old children enrolled in a Head Start program [9, 20]. In North Carolina, by the time children reach kindergarten, 40% have experienced dental decay [21] and about two-thirds of all visits for ambulatory surgery that occurred between 1996 and 1999 in New York state for children less than 6 years of age had a primary diagnosis of dental caries [22]. The rapid rate at which ECC can progress from a non-cavitated lesion or a small cavitated lesion to extensive decay is also an issue of great concern. For example, in two studies among preschool-aged children, the majority of early

ECC lesions observed at baseline in a control group (without any caries preventive intervention) progressed to extensive decay in only one year [23, 24].

ECC affects the health and well-being of young children and can cause pain, infection, negative effects on quality of life and increased expenditures when the child has to be treated for the condition in a hospital's operating room [25]. ECC also can have implications for the future oral health of the child. For example, a longitudinal study from Stockholm reports that 92% of children who had ECC at 2.5 years of age exhibited new carious lesions one year later, compared to 29% of children who were caries free at the baseline exam [23]. The authors concluded that early caries predisposes children to both progression to more severe disease and the development of new carious lesions. Finally, ECC results in lost workdays for caregivers who have to stay at home to take care of their child, or spend time and money in accessing dental care for their child. These lost hours disproportionately affect families of minority, low-income children and children who lack insurance coverage [26].

Treatment of ECC among Medicaid-enrolled children accounts for millions of dollars in expenditures annually [27]. Nainar [28] reports that more than two-fifths of preschool-aged, Medicaid-enrolled children seen at an urban community health clinic in 1997 were treated for dental disease. Kanellis et al. [29] found that fewer than two percent of Medicaid enrolled children less than six years of age received any dental care in the Iowa Medicaid program during 1994. However, the costs for treating these children accounted for 25% of all expenditures for dental care for children, including hospital and anesthesia costs. Although treatment costs are high, nearly 80% of tooth decay among children from low-income families goes untreated [18].

2.3. Access to dental care

Access to dental care for preschool children is a serious problem, especially among those covered by public insurance programs such as Medicaid [30]. The Medicaid program has been the focus of attempts to improve children's access to dental care for several reasons. The program provides health insurance coverage to over 50 million individuals across the U.S., nearly half of whom are children [31]. In 2000, 1 in 5 children in the U.S. were enrolled in Medicaid [32], and it is the single largest public payer for dental care for the poor and near poor. In North Carolina, dental care accounted for 2.4% of all Medicaid expenditures in fiscal year 2004 [33].

Low-income children have access to full insurance coverage, including dental care, through Medicaid. However, they experience the greatest amount of dental disease, have the highest unmet need for dental care, and the lowest rates of dental care utilization of children of any socioeconomic group [34]. Numerous barriers prevent preschool (particularly, low-income) children from receiving the dental care they need. Most general dentists are not trained and/or willing to treat very young children, and there is a shortage of pediatric dentists in the United States [35]. This issue is compounded by Medicaid reimbursement rates for dental care that are below market rates, which makes dentists less willing to see these children [34, 36, 37].

Children enrolled in Medicaid are required to have access to Early and Periodic Screening, Diagnostic, and Treatment (EPSDT) services. These services were created with the intent to detect and correct any health conditions before they hinder the child's learning ability and overall development [32]. These health conditions include iron deficiency, obesity, lead poisoning and dental disease. Specifically for dental care, EPSDT guidelines require that states provide access to screening for dental disease, including relief of pain and infections, restorations and maintenance for all Medicaid eligible children. These dental services are considered a separate category from general health screening services. Although EPSDT guidelines allow oral screenings to be provided as part of general health care services, such screenings are not supposed to be substituted for direct referral to a dentist. Direct referrals to a dentist are required to occur based on the periodicity schedule set by the state, usually by the time the child is three years old, and at other times as medically necessary [38]. However, there is significant variation in the provision of EPSDT services across states, and rates of dental screening and referrals are reportedly low. For example, only 25 percent of children eligible for EPSDT services reportedly received a preventive dental screening in 2003 [39]. In North Carolina, only 34.6% out of 233,454 Medicaid-eligible children birth through 5 years of age received any preventive dental services in 2003 [40]. In a study from Iowa, authors report that although the EPSDT program in that state requires a referral to a dentist at one year of age, less than 4% of Medicaid-enrolled one year old children received any dental services in 1994 [41]. Often cited reasons for underutilization of EPSDT services include low provider participation due to complex rules and administrative burden, and lack of parental awareness about the program [39].

Evidence, although limited, indicates that access to early screening promotes the future use of preventive dental care and lowers dental care related costs. Savage and colleagues [42] found that Medicaid-enrolled preschool age children who had an early preventive dental visit were more likely to subsequently use preventive dental services and have lower dental treatment costs. The benefits gained from access to dental care early in life have led to the proposal for establishment of a dental home for every child. The dental home, similar to a medical home, is a continuous source of coordinated (dental) care and aims to foster mutual responsibility and trust between the healthcare team and the consumer [43]. Although the concept of a medical home has been around for a long time, the dental home is only recently being advocated. The American Academy of Pediatric Dentistry (AAPD) encourages parents and providers to work towards establishing a dental home for every child by his or her first birthday [44].

2.4. Physicians' role in preventing Early Childhood Caries (ECC)

Traditionally, efforts to reduce ECC have included parent education and counseling regarding infant feeding practices, training dental professionals to care for infants and young children, and increasing dental reimbursement rates for Medicaid and the State Children's Health Insurance Program (SCHIP) [10, 45]. However, these efforts have had only limited success in reducing the burden of ECC as indicated by the recent surveillance report from the Centers for Disease Control and Prevention (CDC) [1]. Early intervention strategies that go beyond the traditional dental clinic setting are increasingly being tested to reduce the burden of ECC among preschool children. Such interventions include linking dental screening and risk assessment activities with well-child care or immunization schedules, early establishment of a dental home, and the use of fluoride varnish [3, 46, 47].

Various clinical guidelines recommend that pediatricians and primary care providers take an active role in preventive oral health care of young children [48, 49]. These guidelines and resulting programs are based on the premise that children younger than six years of age are more likely to see a physician than a dentist. The medical office therefore provides an attractive setting for detecting early stage dental disease among very young children.

Additionally, making parents aware of their child's dental health status may increase the likelihood that parents will seek dental care for their child. These benefits in turn may reduce the incidence of dental disease and the need for related treatment and hospitalizations and improve quality of life. In the long term, reduced treatments and hospitalizations potentially may reduce overall Medicaid costs for dental care for this child population.

The primary care setting represents the first point of contact with a healthcare provider for most preschool age children [50]. Primary care principles place emphasis on prevention, continuity of care, and the provision of coordinated and comprehensive health services [45]. The American Academy of Pediatrics' (AAP) Recommendations for Preventive Pediatric Healthcare provide guidelines that have been shown to improve child health irrespective of race, poverty or health status [51]. Additionally, in a study by Yu and colleagues, children with public insurance coverage were more likely to receive the recommended well-child visits compared to their uninsured or privately insured counterparts [52]. Similarly, Dubay and Kenney [53] found that Medicaid-insured children are both more likely to receive health services and have more visits when they visit a healthcare setting than low-income privately insured children. Further, Vivier [54] notes that although a significant proportion of Medicaid-eligible children from low-income families remain uninsured, parents of children report high levels of satisfaction with the well-child care they do receive.

The continuity of well-child care during early childhood also is an important consideration when examining the role that physicians can play in improving children's oral health. Receipt of well-child care is reported to vary significantly by race and family income level [52]. Inkelas and colleagues [50] used data from the National Survey of Early Childhood Health (NSECH), a nationally representative survey of health care quality for young children to examine this issue. The authors report that 98% of children between 4 and 35 months of age have a regular setting for receiving well-child care in the U.S., although only 46% have a specific clinician. Evidence also suggests that adherence to the well-child periodicity schedule is poor among low-income populations. For example, in one Medicaid managed care program, only 35% of eligible children younger than two years of age received all the AAP recommended well-child visits. However, Medicaid enrolled children who have a series of regular well-child visits during the first two years of life experience a reduction in avoidable hospitalizations, regardless of race, poverty or health status [55]. Taken together, findings from these studies suggest that programs that intend to use the medical primary care setting for preventive dental care will need to be aware of these challenges in designing their interventions.

Self-reported data suggest that family physicians and pediatricians are willing to play an active role in ensuring the dental well being of their child patients. In a recent national survey, Lewis et al. [56] assessed pediatricians' knowledge, attitudes and experiences regarding oral health assessment and anticipatory guidance practices. The authors reported that pediatricians believe they can play a role in promoting the oral health of their child patients. The majority of the pediatricians responded that they would be willing to include anticipatory guidance for oral health in their practices. However, only 9% correctly answered all four questions on the survey relating to knowledge of preventive strategies for childhood dental disease. Further, pediatricians stated that they encounter dental decay in their practices regularly, but experience problems in finding a dentist to whom they can refer many of their low-income patients.

In another study, Ismail and colleagues [57] surveyed a representative sample of family physicians and pediatricians in the U.S. The majority of the physicians (91% of pediatricians; 77% of family physicians) reported that they frequently screened young children for gross signs of tooth decay. When presented with case scenarios of two children with mild and severe dental disease, indicating a low and a high-risk child respectively, more physicians recommended that the high-risk child be referred compared to the low-risk child. The authors found that although physicians are capable of deciding whether to refer a child to the dentist based on the child's risk status, most physicians only screen for signs of advanced dental disease on a regular basis, not for early signs of tooth decay.

2.5. Medical office-based dental screening, risk assessment and referral programs

The provision of oral health screenings during well-child visits has been suggested as a way to link dental and medical services during early childhood [58]. Because of the heightened awareness of oral health problems affecting young children and the rationale for such programs, training materials on oral health risk assessment have been developed by a number of organizations including the American Academy of Pediatrics [59]. A number of programs also have been implemented to train physicians and other non-dental personnel to provide preventive oral health services [60]. As many as 12 state Medicaid programs currently reimburse medical providers for some preventive dental services separate from reimbursements for the well-child visit. Yet these programs are recent innovations, so evaluations are rare and scientific evidence to support physicians' activities in this area is limited.

The two key issues related to pediatric preventive dental programs that emphasize oral health risk assessment and referral are those of effectiveness and appropriateness. The issue of effectiveness concerns itself with a physician's ability to provide children with dental referrals that result in a dental visit. The issue of appropriateness relates to the ability of physicians to only refer those children determined to have dental needs, either because of having ECC or being at elevated risk. A systematic review of the evidence for the role of physicians in preventing ECC in preschool aged children concluded that evidence is lacking for the effectiveness of traditionally recommended preventive dental interventions such as risk assessment, screening, referral and counseling [61]. Based on this review, the US Preventive Services Task Force (USPSTF) emphasized the need to strengthen the evidence base for these interventions, with special focus on physicians' abilities to identify dental disease, assess risk and counsel parents about preventive oral health practices. Krol [62] recently reviewed current medical education guidelines, programs, surveys and pediatricians to assess the extent to which oral health related education is a part of the undergraduate, graduate and continuing education programs in pediatrics. He found that overall pediatricians are inadequately trained at these three levels to be able to provide quality preventive oral health care to their child patients.

Very few studies have explored the issues of effectiveness and appropriateness of physicians' oral health screening, risk assessment and referral activities. The systematic review of physicians' roles in preventing ECC identified one case study on the effectiveness of referrals by healthcare professionals in a Women, Infants and Children (WIC) Supplemental Food Program for children 6 months through 5 years of age [63]. The authors found no difference in dental visit rates between children who did (N=89) and did not

(N=220) receive a referral in a multivariate analysis that controlled for child's age, maternal age, household size, presence of dental insurance for the child and the mother's perception of the child's dental needs.

In a study of self-reported physician referral behavior, pediatricians and family physicians self-reported a high level of referral activity [64]. The study involved a cross-sectional survey of primary care practitioners in 69 pediatric and 49 family physician practices. In that study, over 90% of providers reported that they refer infants and toddlers for dental care. Of those providers, almost 80% reported that they refer based on obvious disease or for cases where they believe that the child exhibits early signs of tooth decay. However, despite this high level of self-reported referral activity, at least one study that documented physicians' ability to detect ECC and whether or not they provided referrals indicates that physicians tend to under-refer children with ECC [65]. In that study, only 70% of those identified as having ECC were provided with a referral. Thus it appears that self-reported estimates of referrals provided by physicians may over-estimate the referrals they provide. This issue of under-referral is important because fewer children receiving needed referrals is likely to translate into fewer children using dental care.

Although not examined in great detail this study, the related issue of appropriateness of referrals also is important. A key issue in screening and referral programs is that professional recommendations for the age for the first dental visit are inconsistent. The American Academy of Pediatric Dentistry (AAPD) and the American Dental Association (ADA) recommend that all children be referred to a dentist by one year of age. In contrast, the American Academy of Pediatrics (AAP) recommends that dental referrals be made only for those children up to 3 years of age who have ECC or are at elevated risk for the disease.

These two approaches were evaluated for their effects on dental care use and outcomes for 1- to 3-year-old Medicaid-insured children by Jones and Tomar [66]. The authors report that with excess demand for dental care and fixed workforce capacity, the AAPD/ADA guidelines would increase untreated tooth decay among low-income children because private-pay patients would crowd out low-revenue generating Medicaid-insured children. Results also suggest that adherence to AAP guidelines will likely ensure that children are triaged into the dental delivery system based on risk, that the system will not be over-loaded, and that young children in most need of dental care will be more likely to receive it.

2.6. North Carolina's "Into the Mouths of Babes" (IMB) program

The capacity of the dental care delivery system in NC to meet the needs of very young Medicaid-eligible children is severely restricted. In response to this issue, a comprehensive package has been developed in NC that offers: 1) Dental risk assessment, screening and referral for dental care for the Medicaid enrolled child, 2) Parent counseling and oral health education, and 3) Fluoride varnish application on the child's teeth. Medicaid reimburses physicians for up to 6 such visits before the child's third birthday. The first component of IMB, which is the focus of this dissertation, is aimed at increasing the likelihood of a dental visit and the early establishment of a dental home. Training of physicians in the IMB program follows AAP guidelines on the age of first dental visit [44, 59]. Risk assessment is based on a number of questions modeled after recommendations of Nowak and Warren [67] as well as the AAP guidelines [48]. Participating physicians use the assessment results as a guide in counseling, and provide dental referrals for children with ECC or those determined to be at high risk for the disease. Oral assessments are done in a knee-to-knee position using a directed light source and dental mirror to identify children with dental disease or related symptoms. Physicians are instructed to refer if anything abnormal is detected. Guidelines and training provide helpful hints in achieving a successful referral, such as helping make a dental appointment and having someone in the medical office follow-up with parents.

2.7. Conceptual framework

Figure 2.1 presents the conceptual framework for this study. This framework draws on a systematic review of physicians' role in preventing dental disease among children [61]. Results of this review suggest that primary care clinicians should provide dental screening, risk assessment and referral for dental care as part of medical care of their young patients. The approach is based on triaging children according to risk, where only those with ECC, or those determined to be at elevated risk are referred to a dentist. This approach is more conservative and realistic than other recommendations that suggest all children should be referred to a dentist by one year of age [68]. Adopting this recommendation also is likely to prevent crowding-out of Medicaid insured by private-pay patients as suggested by Jones and Tomar [66].

The selection of study variables is also guided by a model of physician referral proposed by Shortell [69]. Shortell defines a referral as "the process by which one physician transfers responsibility either temporarily, permanently, or for part of the patient's care to another physician or health agency other than an inpatient hospital admission." Shortell views the referral process as a two-stage decision model, where the first stage involves the decision to refer or not. If the physician decides that a referral is needed, then the second stage becomes applicable, which involves the choice of a specific consultant. The author clarifies that, the "first decision determines the volume or rate of referrals while the second determines the pattern" (p. 10). The rate of referral provides a measure of the referral activity occurring within a medical setting; and pattern refers to the nature of this referral, i.e., who refers to whom, and are the referrals mutual or one-way etc.

Shortell's model of physician referral behavior suggests that the rate (and pattern) of referral is a function of patient, physician and community-level variables.

Thus, $R = f\,(P_v, M_v, C_v)$

Where,

R = referral behavior (rates and patterns)

P_v = vector of patient variables – type of illness, severity of illness, age, sex, race, income, marital status

M_v = vector of physician variables – training, organization of practice, volume of practice, years in practice, hospital appointments, professional status

C_v = vector of community variables – size, demographic composition, rural vs. urban, transportation networks etc.

Within this framework, a child who visits a medical provider for a sick- or well- child visit may receive IMB services if this provider participates in IMB and offers the service to this child. Children who are screened and determined to be at high-risk or to have dental disease receive a referral for dental care. Medical practice characteristics (e.g., high Medicaid-enrolled patient volume) are likely to affect the probability of receiving IMB services. Child characteristics (e.g., age, race, Medicaid enrollment history), provider characteristics (e.g., structure of physician practice, Medicaid patient volume), and county characteristics (e.g., number of IMB providers and number of dentists) may affect both the likelihood of receiving IMB and the use of dental care.

Referral practices during an IMB screening and risk assessment visit can have different patterns and varying degrees of success in getting access to dental care for the child. Some providers may detect disease, but still not refer because of the non-availability of a dentist, low self-confidence in detecting a high-risk child or a desire to not burden the parent [65]. Instead they may only advise the parent that the child needs to see a dentist in anticipation of increasing parental awareness about their child's oral health. Other providers may provide parents with addresses of dentists; still others may actually help the parent in setting up dental appointments and also may follow-up with them after the child's dental visit. Parents who were counseled during the IMB visit, but not provided with referrals may still seek dental care for their child due to heightened awareness of their child's dental care needs. If good communication exists between the medical provider and a dentist who provided treatment or other preventive services, we would expect the parents to return to the medical provider for the child's preventive dental care.

The first study aim addresses the likelihood that a child receiving an IMB visit receives a referral for existing disease. The second study aim examines whether, controlling for ECC, a referral facilitates dental use. The third study aim assesses the difference in time to a dental visit attributable to the IMB program, as the increased scrutiny of oral health status by physicians is likely to lead to more efficient and timely referrals for dental care.

2.8. New contributions

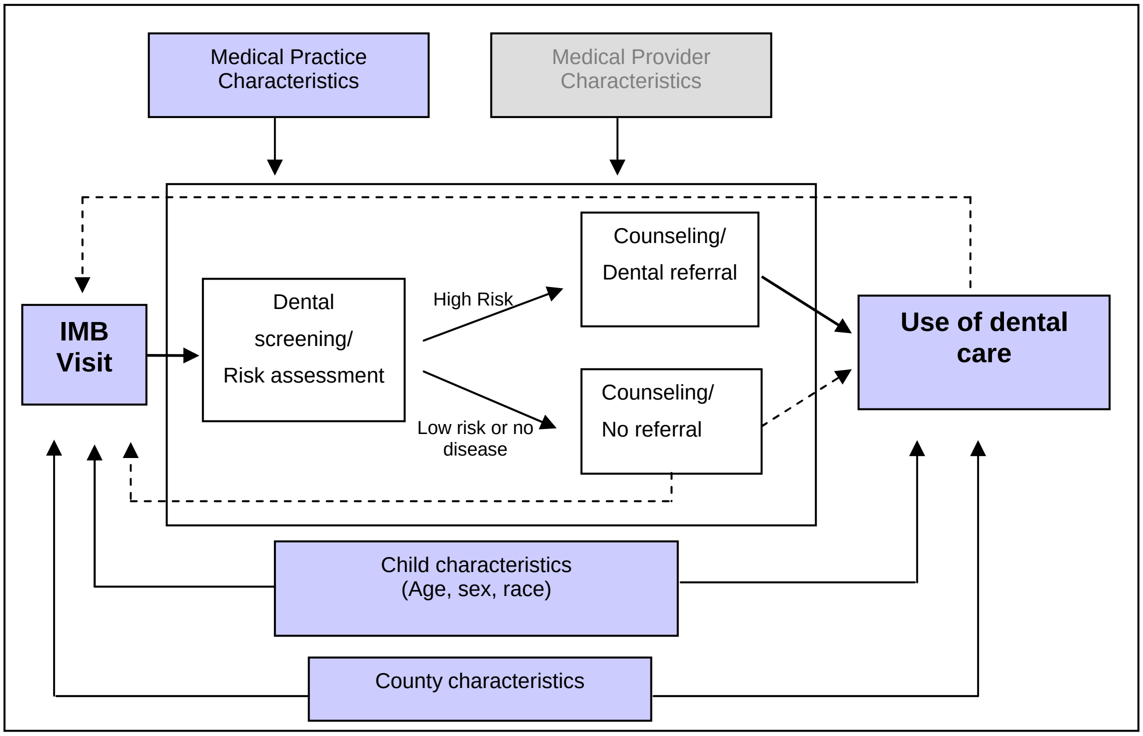
Medical office-based programs that train pediatric primary care practitioners to provide preventive dental services are a recent innovation. Hence, there is little evidence for the effectiveness of such programs, including their role in promoting referrals for and use of dental care by children. A growing number of children in the United States are being born into poverty, which is likely to further increase current concerns about the rising prevalence of ECC [1]. In such a scenario, programs that increase opportunities for children to obtain preventive dental care in settings they already frequent for health care can have a positive impact on their oral health. This study is one of the first to examine the risk assessment and referral aspect of one such program ("Into the Mouths of Babes", IMB) being offered for Medicaid-enrolled preschool age children in North Carolina.

For the first two studies in this dissertation we linked NC Medicaid claims for preventive dental services provided in medical offices with provider-completed patient oral health risk assessment records. This linkage allowed the claims data to be supplemented with valuable information on dental disease status and referral, which typically are lacking from administrative data such as claims. The information on ECC (as reported by the physician) from the risk assessment records allowed an assessment of the appropriateness of physician referrals by examining the proportion of children referred among those identified as having ECC or being free of ECC. A handful of previous studies have found evidence for under-referrals, wherein physicians failed to provide referrals for dental care despite noting the presence of ECC in the child. The current assessment adds to this evidence by providing information on a larger cohort of children than any of the previous studies. The primary limitation of these data is that the number of children included in this study is limited by the number of risk assessment records available to us. Because these records are far fewer in number than the claims, they limit the sample, and likely the extent to which findings from this study can be generalized. Nevertheless, this study provides one of the first assessments of ECC, referrals and use of dental care within a medical model for the delivery of preventive dental care to a low-income child population.

An additional strength of all three studies that are part of this dissertation is that we use information on referrals and use of dental care from either the patient records or claims, and do not rely on self-reported data from either the providers or parents. Further, the third study in this dissertation provides an assessment of the effect of practice participation in a preventive dental program on access to dental care for children seen in those practices. The data for this study are Medicaid claims from 2004-2006. As such, this analysis provides a useful assessment of the effect of IMB from a time of widespread and stable implementation of the program in North Carolina.

The provision of preventive dental services in the pediatric primary care setting is increasingly recognized as one way of linking dental health care to medical health services during early childhood. This approach addresses recent calls to develop “systems” to facilitate children’s health and development [2]. The three studies in this dissertation provided an opportunity to examine one such system of care that uses the primary medical setting to identify children in need of dental care and to facilitate their access to and use of dental services, which they likely would otherwise be unable to obtain.

Figure 2.1. Conceptual framework



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3. METHODS

3.1. Overview of Methods

The manuscripts in chapters 4, 5 and 6 pertain to the three studies that are part of this dissertation. The three manuscripts will be referred to as Study 1, Study 2 and Study 3. The methods sections of these three manuscripts contain some redundancies with this chapter of the dissertation which provides an overview of the methodology used for the three studies. The sample used for Study 1 and Study 2 are the same, but not for Study 3. The methods used to analyze the study questions addressed by the three manuscripts also are different. The two main data sources for studies 1 and 2 were physician-completed child risk assessment records (Encounter Forms, EFs) from 2001 and 2002 that were combined with NC Medicaid claims. For the third study, claims data from January 1, 2004 through December 31, 2006 were used.

Several other data sources were linked to the EFs and claims for all three studies. These data sources included the following: (1) Area Resource File, which provided information on county-level population estimates [1]; (2) The North Carolina Health Professionals Data System (NCHPDS), which is available through the University of North Carolina's Cecil G. Sheps Center for Health Services Research, and provided county-level information on the number of dentists [2]; (3) a verified list of pediatric dentists in each NC county obtained from the Department of Pediatric Dentistry at UNC-CH; (4) The NC Community-Level Information on Kids (NC-CLIKS) database that provided county-level data on number of children (age 0-17 years) enrolled in Medicaid in every NC county for 2001 [3]; and (5) county-level water fluoridation status that was obtained from the Oral Health Section of the NC Department of Health and Human Services [4].

3.2. Research Design

Study 1 uses a retrospective cohort design to examine factors that predict the likelihood that a child will be referred for dental care by their primary care physician. Studies 2 and 3 in contrast use a prospective cohort design to assess use of dental care following a referral (Study 2) or a well-child visit (Study 3). Both Study 1 and 2 use the first EF for the child as evidence of the child's first IMB visit. For study 2 we follow children until they have evidence of a dental claim, a second IMB visit or six months from the date of their first IMB visit (referred to as a "failure event" in survival analysis terms). For Study 3 children are followed forward from their first well-child visit until they have a dental claim or are censored due to the end of their Medicaid eligibility or the end of the data (December 31, 2006).

We chose to use the presence of a dental claim rather than evidence of a treatment or preventive visit as the failure event because the focus of this study was on the effect of the physician referral in promoting use of dental care, not on the appropriateness or type of care needed. The six month window (for Study 2) was chosen because there is evidence that Medicaid-insured patients often face long waiting times between making a dental appointment and being able to see the dentist [5]. Children with special health care needs were excluded from all analyses, as they are likely to have very different medical and dental referral and treatment needs and dental use patterns. These children were identified by their reason for Medicaid eligibility from the claims data.

3.3. Measurement

The dependent, main explanatory variables and control variables for the three studies are presented in Table 3.1. For the regression model in Study 1, the dependent variable measures whether the child received a physician referral for dental care or not. For Study 2, the dependent variable is the time from when a physician referral occurred to the use of dental care by the child (as evidence by a dental claim). The first two analyses were restricted to children who have a dental screening and risk assessment form completed as part of the IMB program and available for analysis. For Study 3, the dependent variable was the length of time to a dental visit following the child's first well-child visit.

3.4. Data Sources

The main data sources for this dissertation are the Medicaid claims and child oral health risk assessment records (Encounter Forms, EFs) completed by providers at the child's first IMB visit. These two data sources were supplemented with county-level data from five other sources which are described in section 3.4.3.

3.4.1. Medicaid claims files

The main sources of data for this study are the medical and dental Medicaid claims and enrollment files for all children less than 6 years of age who were enrolled in Medicaid from October 1999 through December 2006 that were obtained from the NC Division of

Medical Assistance (DMA) for assessing the overall effectiveness of IMB in reducing total treatments for early childhood caries. A third file containing information about medical providers participating in the NC Medicaid program during the same time period was also available.

Dental claims provide detailed information about all services for which Medicaid reimbursement was requested by dental providers in NC. Variables in these claims files allow for identification of the types of dental procedures and whether care was delivered in a private dentist's office, at a community health clinic or in a hospital. This file also contains information about claims submitted by physicians for well-child or other office visits with and without IMB services. The enrollment files provide information about the length of time that children were enrolled in Medicaid. The medical provider file contains the Medicaid billing number for medical practices, which allows identification of the medical practice where a medical visit occurred. Henceforth, these three datasets (enrollment, claims and provider file) will be referred to as the "claims data."

3.4.2. Child encounter forms

Physician-completed encounter forms (EFs) provide information about the child's dental disease and risk status, parental reports about feeding and oral hygiene practices, an IMB visit indicator (i.e., the sequence number of the current visit of a total of 6 possible visits), whether the physician told the parent that the child needed to see a dentist, and whether a referral was made. Information regarding the dental provider is also recorded on the EFs for children who are referred for dental care. For example, we know whether the parent reported already having a dental provider for the child, or if the referral was made to a health department's dental clinic, to a private general dentist, or to a pediatric dentist. Encounter forms are available for children who received IMB services from 2000 through 2004 (N~50,000 children and 77,000 IMB visits). Completion of EFs was not required after 2004. Data from the EFs and claims were merged using Medicaid ID numbers and is described briefly in section 3.5. A detailed description of the process of matching EFs to claims data is provided in a manuscript included as Appendix B in this dissertation. The match rate was approximately 90% for EFs and claims for the period from 2000 through 2002, and about 90.4% for 2003. At the time of matching claims to EFs, we had claims for 2003 only until June, so the latter match rate is calculated based on the first six months of 2003 only.

3.4.3. County-level data

The Area Resource File (ARF) was used to obtain demographic characteristics of the 100 counties in NC. The ARF is publicly available and is maintained by the Health Resources and Services Administration [1]. Additionally, the number of general dentists and primary care physicians per county were obtained from the North Carolina Health Professionals Data System (NCHPDS), which is also publicly available through UNC's Cecil G. Sheps Center for Health Services Research [2]. A verified list of pediatric dentists in each NC county was obtained from the Department of Pediatric Dentistry at UNC-CH. The NC Community-Level Information on Kids (NC-CLIKS) database provided county-level data on number of children (age 0-17 years) enrolled in Medicaid in every NC county for 2001 [3]. Finally, county-level water fluoridation status was obtained from the Oral Health Section of the NC Department of Health and Human Services [4].

3.5. Linkage of Data Files

As mentioned previously, child encounter forms and claims were linked for studies 1 and 2. The process of linking these two data sources is described in detail in a manuscript titled, "Agreement between structured checklists and Medicaid claims for preventive dental visits in primary care medical offices" [6], included as Appendix B in this dissertation. Briefly, NC Medicaid enrollment and claims files were matched with patient records of preventive dental visits (encounter forms, EFs) using individual-level information in both data sources. To be included in the linked dataset, medical practices were required to have a minimum of 10 EFs and claims for preventive dental visits. We chose this threshold to eliminate practices that participated in continuing medical education (CME) to make them eligible for reimbursement from Medicaid, but never fully adopted the practice. The data linkage process for this study involved two steps. In the first step, the EF database was linked to NC Medicaid enrollment information using the child's name, date of birth and Medicaid ID. In the second step, the child's Id and date of visit were used to match preventive dental visits recorded in the EF with a similar visit recorded in the claims database.

In total, 34,171 matches were found between 41,252 EFs and 40,909 claims, representing 82.8% of EFs and 83.5% of claims, with a child-level match rate of 82.5%. Agreement on visit frequency was 56% overall (weighted kappa=.66). Pediatric practices provided the majority of visits (82.4%) and matches. Increasing age of child and residence in the same county as the medical practice increased the likelihood of a match. Compared to pediatric practices, family physician practices were more likely to have unmatched EFs than matched EFs and claims. We concluded that both patient records and claims can have gaps, but insurance claims are the most complete dataset for assessing preventive dental visit frequency. However, the match rate of 82.5% shows that multiple data sources can be combined to evaluate the effectiveness of preventive programs.

Further, for all three studies, the identifier for the child's county of residence from the claims was used to merge information on water fluoridation or urban/ rural classification of the child's county with the analytic file. For Study 1 and 2, county-level information from the ARF, the NCHPDS, number of pediatric dentists and information on Medicaid-enrolled population in NC counties from NC-CLIKS was merged with the analytic files using the identifier for the county where the medical practice is located.

3.6. Sample and Statistical Power

The sample used for the first two studies consists of the approximately 50,000 children with 77,000 completed encounter forms that were linked to claims data. The analyses for these two study aims are descriptive, and focus on identifying factors associated with receipt of a referral from an IMB physician and time to a subsequent dental visit, so these analyses were conducted using the available sample.

However, Study 1 also includes a hierarchical model that estimates the separate effects of child and practice characteristics on the likelihood that a child will receive a referral. Because of the clustering of observations (children clustered in medical practices), intra-practice correlations among observations would require higher power to detect the referral effect for a given level of statistical significance compared to the scenario where such intra-practice correlations do not exist [7]. Initial work with practices participating in IMB indicates that pediatric practices may have higher referral rates than family practices. Therefore the ability of the regression model to detect these differences in referral rates would require sufficient power, which is calculated below. In the available encounter form data, there are approximately 123 pediatric practices and 151 family practices. Although, a third group of health departments or other community clinics also exists, it is difficult at this stage to tell whether the medical provider in either of these settings was a physician, pediatrician or a nurse practitioner. Therefore this group is not included in the power calculations.

Power (1-β) is calculated using the following formula [8],

$$1-\beta = \Phi\left(\frac{\delta}{\sqrt{\{\mathrm{var}(d)\}}}\right) - z_{1-\alpha/2}$$

Where, $\mathrm{var}(d) = \sigma_1^{\,2}/n_1 + \sigma_2^2/n_2$, and n_1 and n_2 are the number of pediatric and family practices that were participating in the IMB program from 2001 through 2002, respectively. The value of *var (d) = .00001472*. The value of σ^2 is calculated as,

$$\sigma^2 = \frac{1}{m}\{[\pi_{h1}(1-\pi_{h1})][1+(m-1)\alpha_0]\}$$

The average number of children in each pediatric practice are, m_1=34 (41882/123), and for a family practice, m_2=63 (9547/151). π_1 (769/41882 = .0184) and π_2 (351/9547 = .0368) are the proportion of children who received a referral for dental care in pediatric and family practices respectively, and $\delta = \pi_1 - \pi_2$ (.018). The design effect α_0 is calculated as: α_0=1 + (m-1) ρ). The median intraclass correlation coefficient ICC (ρ) across patients following adjustment for individual and cluster-level variables is reported to be 0.005 for cluster-based studies in primary care settings [7]. For an ICC of 0.005, we get α_0=1.83, σ_1^2 = .000972 and σ_2^2 = .001030. Thus we get a power (*1–β*) value of 99.7 to detect a difference in referrals for children seen in pediatric practices versus those seen in family practices. Because this calculation accounts for clustering of children within practices, it gives an indication that sufficient sample is available to detect significant differences in referrals even with the presence of clustering (which usually increases the sample size requirements).

Study 3 focuses on the effect of being seen in practices participating in IMB versus non-IMB practices on differences in the time to a dental visit. Therefore, sample size calculations are needed for Study 3 to ensure that a sufficient sample will be available to detect the effect of being in an IMB practice on dental use. The sample for the third study is the entire population of children aged 6 through 35 months of age who were eligible and enrolled in the NC Medicaid program from January 1, 2004 through December 31, 2006. Rates of visits to dentists vary by age of the child. Unpublished data from our analysis of the total effect of IMB using Medicaid claims from October 1999 through June 2003 show that the rate of dental visits among children without IMB visits is 0.55% per month at 30 months of age.

First, we calculate the required sample size to determine the effect of IMB on referrals for treatment of disease discovered during the first IMB visit for a child who is 30 months of age, ignoring the clustering by practice (which increases the sample size). Under this simple scenario, for a 5% level of significance with 80% power, we would need 7,100 children of age 30 months in each group (i.e., in practices conducting and not conducting IMB) to detect an increase in the referral rate of 20%. Preliminary analyses of the encounter form data show that about 38% of IMB recipients with provider identified disease were given a referral for a dental visit, so the idea that the referral likelihood would increase by 20% is conservative.

3.7. Multiple imputation of dental caries data

Physician-reported dental caries status of the child is important variable for the first two analyses that focus on predictors of referrals and time to use of dental care subsequent to a referral. This information was available to us from the encounter forms. However, it was missing for about 22% of the study sample. We therefore imputed this missing data using a random effects zero-inflated poisson model that accounted for the hierarchical nature of the data, the excess zero values commonly seen with dental caries data and its overall poisson distribution. The multiple imputation process resulted in 20 completed datasets with imputed dental caries information, therefore all analyses presented for Study 1 and 2 use the SAS® procedure PROC MIANALYZE to obtain average values for the estimates and standard errors across these 20 datasets. Details about the process used to impute the dental caries data are included as a technical appendix (Appendix A) at the end of this dissertation.

3.8. Overview of Data Analysis

3.8.1. Appropriateness and predictors of physician referrals for dental care (Study 1)

3.8.1.a. Appropriateness of physician referrals for dental care

Descriptive analyses of the child EFs provide unique information about rates and appropriateness of dental referrals in the IMB program. The measure of appropriateness is the number of under and over-referrals. We assess under-referrals based on the number of the children with physician-identified ECC who did not receive a referral. This assessment of appropriateness however is limited because we lack information on physician-assessed oral health risk of the child. For the same reason we were limited in our assessment of over-referrals, wherein children without physician-identified ECC might have received a referral because of being at elevated risk.

3.8.1.b. Predictors of physician referrals for dental care

A binary variable (yes/ no) related to referral on the child encounter forms indicates whether the physician referred the child to a dentist. We hypothesized that child, medical practice and county-level variables, e.g., presence of dental disease, high volume of Medicaid-insured patients and dentists/10,000 population, are likely to affect the probability of receiving a referral. In order to model this hierarchy (i.e., children nested within medical practices), we used the hierarchical modeling framework. Hierarchical/ variance components models are a category of mixed models that allow for simultaneous estimation of the effects of covariates at multiple levels of naturally occurring hierarchies on the dependent variable of interest [9].

A two-level hierarchical logit model of children nested within medical practices provided estimates of child, and medical practice characteristics that influence the likelihood of referral for dental care. Random intercepts at the practice-level allowed the probability of referral to vary across the sample of medical practices. In this model, y_{ij} is the binary dependent variable indicating whether child i in practice j received a referral for dental care. The model estimates the probability of referral as $Pr(y_{ij} = 1)$, where y_{ij} is modeled using a logit link function and assumes that y_{ij} has a Bernoulli distribution conditional upon the random effect. At the child level we model the log odds of referral for each child as a function of a medical practice-specific effect and child-level covariates. The model at the practice-level similarly models the average log odds of referral for each practice as varying around, via a practice-specific random effect, an overall average log odds of referral adjusting for practice.

Wright and colleagues [10] note that unlike continuous dependent variables, the mean and variance of a binary dependent variable are not independent from each other. This requires that the variance components model be estimated on the log-odds scale. The coefficients from the variance components model (with covariates), can be interpreted either in terms of odds ratios or predicted probabilities [11]. For example, if the coefficient on the child's sex (male=1) is –.661 then the odds ratio interpretation would indicate that everything else being equal, male children are about 100% – exp (–.661)*100 = 48.4% less likely to be referred for dental care than female children.

Further, because logit is a non-linear model, the marginal effects on the probability scale of the explanatory variables on the dependent variable are not constant for all values of the explanatory variables. Thus, in order to compute the marginal effects for the statistically significant variables we calculated estimates, via simulation, for an average change in the probability [12] of observing the dependent variable given a one-unit increase in the continuous variable, e.g., age. For dummy variables (e.g., child has dental caries or not), the calculation provided an average probability for observing the data e.g., given a change in the child's status from being disease free to having ≥1 tooth with decay. The marginal effect calculations were done twenty times, one for each of the twenty imputed datasets. We present results for the median, and the 25th and 75th percentile of these marginal effects to show the range of marginal effects values.

3.8.2. Time to a dental visit following a physician referral for dental care (Study 2)

This study assesses the effectiveness of dental referrals provided by physicians participating in IMB in promoting use of dental care among children who received IMB screening and risk assessment services. We hypothesized that children who received a referral will have shorter time to dental utilization than those not referred for such care. Limited information exists in the literature on the length of time it takes for an individual to seek and obtain dental care following their receipt of referral for such care. There however is evidence that individuals enrolled in public insurance programs such as Medicaid can face a waiting period of as long as four or five months between making their dental appointment and actually seeing the dentist [5]. One study from the medical literature examined the time to presentation at a hospital following referral (by medical and dental practitioners) for invasive squamous cell carcinoma among 100 patients [13]. The authors of that study reported that only 39% of patients presented at the hospital within four weeks of receiving a referral, and 29% delayed their hospital visit to more than 3 months. Based on findings from these two studies, we made the decision to follow children for a period of six months following their first IMB visit to track dental visits. However, in order that we may be able to connect a referral to a subsequent dental visit, children who had a second IMB visit before that six month period were censored at that time point.

We estimated Kaplan-Meier survival curves for time to use of dental care by referral status (yes or no) and tooth decay status (yes or no). The log rank test was used to examine whether the presence of tooth decay (as recorded on the EF by the physician), and conditional on a referral, influences children's use of dental care by testing for the equality of the survivor functions [14]. For the multivariate analysis, child and medical practice characteristics were entered into a Cox proportional hazards model to predict the time to utilization of dental care subsequent to a referral among children who received IMB screening and risk assessment services as a function of child, medical practice and county characteristics.

From the literature and our prior analyses, we know that many children are not continuously enrolled in Medicaid, although many gaps are due to administrative processing rather than non-eligibility for services. Therefore, data for many children are likely to be censored. Left censoring, where children might already have visited a dentist before receiving a physician referral, may not be a substantial problem because many of these children will regain eligibility for Medicaid when covered services are needed. However, it is still possible to have left censoring if the child used dental care that was paid for out-of-pocket or by private insurance. We were unable to control for this in our analyses, however the overall low rates of dental care utilization in a preschool age population [15] makes this possibility a small concern for the overall analysis. Finally, although there is a possibility that children might receive referrals for dental care more than once, their number is small. In our analysis of all encounter forms for 2001 and 2002 (N=43,117), we found that the majority of the referrals (71%) occurred at the first IMB visit, and about 22% received a referral at their second IMB visit. The analysis strategy for this study therefore only models the first referral and the first dental visit subsequent to that referral.

3.8.3. Effect of practice participation in IMB on access to dental care (Study 3).

This intent-to-treat (ITT) analysis assesses the overall effectiveness of IMB in promoting access to dental care. An ITT effect is the average effect on the dependent variable (i.e., use of dental care) among those who were targeted for the intervention (i.e., children accessing care in practices participating in IMB), regardless of whether they received IMB screening and risk assessment services or not [16]. Participation in IMB has been increasing over time since its statewide implementation in 2001 [17]. Non-dental healthcare providers including, pediatricians, family physicians, and to a smaller extent, registered nurses, nurse practitioners and physicians assistants from 310 practices were trained during 2001 and 2002. These 310 practices included 116 pediatric practices, 93 family physician practices, and 101 community health agencies or residency programs. The program has achieved wide geographic coverage of the state and by the last quarter of 2002 only sixteen of the state's one hundred counties had no pediatrician, family physician, or local health department participating in the program. The program has continued to expand, and at the end of 2006 there were over 400 practices providing IMB services.

This is a prospective cohort study of children born on or after July 1, 2003 who were enrolled in the NC Medicaid program during January 1, 2004 through December 31, 2006 and received well child services during that time period in pediatric and family physician practices across NC. The medical practices providing well-child services were classified into IMB participating practices or not, and those identified as IMB participants were further divided into two groups based on whether their participation in IMB was of a high or low intensity. We were interested in estimating separate effects for high and low IMB participants because there is wide variation in the extent to which practices participate in the IMB program, which likely also affects their referral activity. The intensity of IMB participation was defined based on three-month moving averages of the number of IMB visits that occurred in the practice as a proportion of the well child visits for Medicaid-enrolled children during 2004-2006.

We further selected children within these practices that had evidence of a claim for a well-child visit during the same time period. Child-level data were aggregated to the practice-level and stratified children into three age groups (<=12 months, 13-24 months and 25-36 months) from rural and urban counties. The stratification also accounted for the number of months between the child's first well-child visit and dental visit or censoring due to end of Medicaid eligibility or end of the data. We expected that children who make a dental visit soon after their well-child visit likely do so because of being identified as having disease or being at risk for decay. We therefore examined the time from the child's first well visit to the dental visit using five categories (03-, 4-6, 7-12, 13-24 and 25-36 months). The dependent variable (number of dental visits) in the aggregated data was modeled as a poisson count, with the time to the child's first dental visit from his or her first well-visit as the offset (denominator) in a piecewise exponential model. Model estimates provide comparisons of survival rates for children seen in the three types of medical practices (practices providing WCV services only, WCV + High IMB practices and WCV + Low IMB practices), for the three age groups from rural or urban counties over each of the five time periods.

The hypothesis to be tested for Study 3 is:

Medicaid-enrolled children seen in medical practices participating in IMB will have a shorter time to use of dental care from the time of their first well child visit compared to Medicaid-enrolled children seen in medical practices not participating in IMB.

In an ideal situation, only children needing dental care would be referred, therefore we focused on the child's first IMB visit (when disease would likely be detected, if present). Use of dental care was defined similar to Study 2, where the first dental claim for the child (following the child's first well child visit) was considered as evidence of a dental visit. Although dental treatment also can be provided in a hospital setting (inpatient or outpatient), those visits were not be considered for this analysis. The reason being that hospital-based dental treatment is very different from dental care provided in a clinic setting, and the purpose of this research is to examine whether a dental referral provides the child with an opportunity to potentially gain access to a regular source for dental care.

Table 3.1. Description of study variables

Variables	Source*£	Type
Dependent Variables		
1. Received physician referral for dental care (among children receiving IMB)	2	Dichotomous
2. Time from IMB visit to use of dental care	1 & 2	Continuous
3. Time from first well-child visit to use of dental care	1	Continuous
Other explanatory/control variables		
Child-level variables		
Child's age (in months)	1 & 2	Continuous
Child's sex	1 & 2	Dichotomous
Child's race/ethnicity (White, American Indian, African American, Asian, Hispanic, Other)	1 & 2	Dummy variables
Indicator for dental visit	1	Dichotomous
Number of well-child check ups	1	Continuous
Number of sick-child check ups	1	Continuous
Indicator for well- or sick-child visit	1	Dichotomous
IMB screening/risk assessment received or not	1 & 2	Dichotomous
IMB service received in health department, pediatric practice or family physician practice	1	Dichotomous
Number of perceived cavities	2	Categorical
Water fluoridation status of child's county of residence	3	Categorical
Rural/ Urban status of county where child was living at time of first well-child visit	4	Categorical
Medical practice-level variables		
Volume of Medicaid-insured patients	1	Dichotomous
Average Medicaid enrollment in months	1	Continuous
Number of children receiving IMB screening and risk assessment services	1 & 2	Continuous
Rural/ Urban classification for county where medical practice located	4	Categorical
County-level variables		
Number of general dentists	4	Continuous
Number of pediatric dentists	4	Continuous
Number of physicians/ 10,000 population	4	Continuous
Number of IMB provider practices	1	Continuous
Number of Medicaid eligibles per age 0-17 population	4	Continuous

* Sources: 1. NC Medicaid claims data, 2. Patient encounter forms, 3. NC Oral Health Section, 4. Area Resource File (ARF)/ NC Health Professional Data System (NCHPDS)/ UNC-CH Dept. of Pediatric Dentistry

£ Variables available from the child encounter forms cannot be used for regression models under Study 3

3.9. References

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4. PREDICTORS OF REFERRALS FOR DENTAL CARE FROM A MEDICAL OFFICE-BASED PREVENTIVE DENTAL PROGRAM

4.1. Abstract

Objective: To evaluate the appropriateness and predictors of physician referrals for dental care in an innovative program ("Into the Mouths of Babes", IMB) that expands access to preventive oral health services in the pediatric primary care setting for Medicaid-enrolled preschool aged children in North Carolina (NC).

Data sources: NC Medicaid claims for 2001 and 2002 merged with dental risk assessment forms completed by participating medical providers.

Study design: Cross-sectional study that used two-level random intercept hierarchical models to examine the effect of dental caries at the child-level and provider characteristics on the likelihood that a child will receive a referral for dental care. Analyses were conducted with the entire sample, and also by using location of medical practice (metro vs. non-metro county) as a stratification variable.

Principal findings: Among children with at least one decayed tooth, about 33% were referred. Among children who received a referral, 41.9% had no indication on the child's record of Early Childhood Caries (ECC). The probability of referral was higher for children with ECC by 22 percentage points (vs. children without ECC) and for those seen in practices in non-metro vs. metro counties. Number of children in practice with dental caries in the past three months and availability of general dentists in metro counties positively predicted practice-level likelihood of referral. The availability of general dentists in a contiguous county to a non-metro county predicted practice-level likelihood of referral in non-metro counties.

Conclusions: Physicians participating in the NC IMB program conducted dental risk assessments and provided referrals for many but not all children in need of dental care. Future research needs to examine strategies to improve physicians' referral practices.

Key words: Medicaid, Early Childhood Caries, dental referral, low-income children, primary care, oral health risk assessment

4.2. Introduction

Dental caries among preschool age children (Early Childhood Caries, ECC) is a matter of growing concern among healthcare professionals, researchers and policy makers. The most recent report from the National Center for Health Statistics indicates an increase in the prevalence of ECC from 24% during 1988-94 to 28% during 1999-2004 [1]. Five times more common than asthma [2], ECC, which includes treated and untreated caries, is the most common preventable chronic disease encountered among children of preschool age in the U.S. [3]. Disparities in untreated ECC are severe, wherein preschool-aged children from low-income families experience five times more untreated decay than their high income counterparts [4, 5]. For example, one study found an ECC prevalence as high as 90% among 3-to-5 year old children enrolled in a Head Start program [4]. Numerous barriers prevent preschool age children, particularly those in low-income families, from receiving the dental care they need. Most general dentists are not trained and/or willing to treat very young children, and there is a shortage of pediatric dentists in the United States [5]. Poor access is compounded by Medicaid reimbursement for dental care below market rates. These reimbursement rates often are at 40% of the usual, customary and reasonable fees charged by dentists, which makes dentists less willing to see these children [8-10].

Professional guidelines, including those from the American Academy of Pediatrics (AAP) recommend that healthcare providers serving pediatric populations should screen children for ECC during routine medical visits beginning at six months of age [6-8]. These screenings are important, particularly for low-income, pre-school age children because they can facilitate early detection of ECC in young children who frequently have medical visits but rarely make dental visits. The AAP further recommends that children younger than three years of age who are identified as having ECC or are considered to be at elevated risk should receive a referral to a dentist by their physician. However, little is known about factors that determine if referrals are made or not, or the appropriateness of these referrals when made. These questions have taken on increasing importance because of severe limitations in access to dental care for low-income children enrolled in public insurance programs and because of a number of recently implemented programs that encourage non-dental health care professionals to provide preventive dental services for young children [9, 10].

Most physicians self-report in national surveys that they are likely to conduct screenings for dental risk factors and obvious tooth decay [14, 15]. Pierce and colleagues examined pediatric primary care providers' ability to identify children with ECC or those at elevated risk and appropriately refer them to a dentist [11]. The study was conducted with eleven pediatricians and a nurse practitioner at a private pediatric group practice serving a high volume of Medicaid-insured children. The providers received two hours of training on infant oral health issues including viewing clinical slides of children with various degrees of ECC. They were then asked to examine 258 preschool age children and refer any child with one or more decayed tooth, soft tissue pathology or those with trauma to the teeth or mouth. Providers' ECC evaluations and referral decisions were compared to a pediatric dentist, considered the gold standard for the study. The pediatric providers had a sensitivity of .76 and a specificity of .95 in identifying children with ECC. Overall however, the providers had a tendency to under-refer, with only 70% of children with ECC receiving a referral.

A cross-sectional survey of primary care clinicians in 69 pediatric and 49 family physician practices further examined medical providers' characteristics that predict whether they would provide the needed referrals to a dentist for children in need of dental care [12].

The authors used a self-administered questionnaire to elicit information including, clinicians' knowledge and opinions on various aspects of providing referrals to dentists. Most (78%) of the 169 participating clinicians responded that they were likely to refer children who either had early tooth decay or exhibited signs of being at risk for decay. In a logistic regression model, an increased odds of referral was associated with clinician confidence in their ability to screen for tooth decay, low perceived level of difficulty in making the referral, and being in a group practice. High volume (>60% of patient population) of infants and toddlers was associated with a decrease in the odds of referral. Providers' knowledge and opinions about oral health did not predict the likelihood of a referral. In this study of self-reported behavior, the referral environment was considered to be more important than physicians' oral health knowledge and patient characteristics in determining whether children at risk for decay would be referred to a dentist or not.

The purpose of this study is to extend the knowledge base in the area of factors that predict children's referrals to dentists by their primary care physicians and the appropriateness of these referrals. One of the earliest efforts to increase access to preventive dental care in the pediatric primary care setting began in North Carolina (NC), and is the context for this study. After several years of pilot testing, the NC Medicaid program began reimbursing pediatric and family physician practices and health departments in January 2000 for preventive dental care for Medicaid-enrolled children under the "Into the Mouths of Babes" (IMB) program [10]. One component of the IMB program involved training providers to conduct oral health risk assessments and provide referrals to dentists for those children determined to have dental needs. The oral health risk assessment training provided to practitioners as part of IMB uses the American Academy of Pediatrics guidelines [7] that recommend referring to the dentist before three years of age only those children with ECC or those at high risk for the disease. The purpose of this study therefore was to determine whether physicians participating in a medical office-based program of pediatric preventive dental care are providing dental referrals for children, and to determine the predictors and appropriateness of these referrals.

4.3. Methods

Overview of study design and analysis

This is a cross-sectional study of Medicaid-enrolled children who had their first IMB visit in participating medical practices. We combined Medicaid claims data, patient oral health risk assessment records completed by physicians and other information sources to examine the likelihood that a child would be referred to a dentist. Because one of our interests was in understanding the distinct effects of child- and practice- level characteristics on the likelihood of receiving a dental referral, we used a hierarchical modeling framework to conduct our analyses. We only examined the issue of appropriateness of referrals for children identified to have ECC. The lack of information on ECC risk factors prevented us from examining whether children who received referrals despite being identified as ECC free by the provider were indeed referred because they were considered to be at risk for ECC.

Study population

This study included children 6 through 36 months of age who received preventive dental services during 2001 and 2002 in the NC IMB program. According to NC Medicaid policy in effect during the period of this study, participating providers could submit claims for preventive dental services provided during well-visits or other office visits every 90 days for a maximum of 6 visits before the child's third birthday. In order to receive any reimbursement from NC Medicaid for providing IMB services, medical practitioners are required to provide all of the following three services at each visit: (1) screening the child for risk of or presence of ECC and referral to a dentist if needed; (2) topical fluoride application on the child's teeth; and (3) parent education about infant oral health care practices.

Data Sources

Data for this study came from the following sources:

1. Medicaid enrollment and claims files

Medicaid claims and enrollment data for all children in the study were obtained from the NC Division of Medical Assistance (DMA), the agency responsible for administering the Medicaid program in NC. Medicaid data provided detailed information about claims submitted by physicians for office visits with and without IMB services. The enrollment files provided information including, the child's date of birth, race, sex and county of residence. A third file containing information about medical providers participating in the NC Medicaid program for the study period was used to identify characteristics of the practice where a medical visit occurred. Henceforth, these three datasets (enrollment, claims and provider files) will be referred to as the "claims data."

2. Patient encounter forms (EFs)

During the demonstration phase of the NC IMB program (2000 through 2004) physicians were instructed to complete encounter forms (EFs) for each IMB visit in addition to submitting claims for reimbursement. They voluntarily forwarded a copy of each EF to the demonstration project office for data entry. EFs provided additional information about the child's dental caries and risk status, parental reports about feeding and oral hygiene practices, an IMB visit indicator (i.e., the sequence number of the current visit of a total of 6 possible visits), and whether the physician referred the child to a dentist. EFs completed by physicians were not collected after 2004.

Electronic records of EFs are available for children who received IMB services from October 2000 through 2003 (N~50,000 children and 77,000 IMB visits, 1.5 EFs per child). Data from the EFs and claims were merged using Medicaid identification numbers. The match rate between encounter forms and claims was approximately 90% for the period from October 2000 through June 2003 [13]. Based on our analysis of the completeness of EFs compared to claims, we found that physicians were most likely to complete EFs at the child's first IMB visit. We therefore restricted the analysis for this study to the child's EF completed at his or her first IMB visit. Because claims were not available for all months in 2003, we restricted the EFs to 2000 through 2002. Further, because the number of EFs for year 2000 was less than 50, with a majority having missing information on the key variables in this study, the sample was further restricted to data from 2001 and 2002. Application of these criteria resulted in a total of 29,528 EFs being available for the current study.

3. County-level data

The Area Resource File (ARF) was used to obtain demographic characteristics of the 100 counties in NC [14]. County-level information on the number of dentists were obtained from the North Carolina Health Professionals Data System (NCHPDS) [15]. In addition, a verified list of the number of pediatric dentists in each NC county was obtained from faculty in the department of pediatric dentistry at UNC-CH. The NC Community-Level Information on Kids (CLIKS) database was used to obtain county-level data on number of children (age 0-17) enrolled in Medicaid in every NC county [16]. County-level water fluoridation data were obtained from the Oral Health Section of the NC Department of Health and Human Services [17].

Conceptual framework

The framework for our analysis draws upon work by Shortell (1972), who proposed a model for physician referral behavior in which various patient, physician and community-level variables influence the rate (and pattern) of referrals [18]. Shortell's model of physician referral behavior suggests that referral is a function of patient (type and severity of illness and demographics), provider (type, busyness) and community-level variables (rural vs. urban). We also draw on a framework of physicians' role in preventing ECC among children identified by the U.S. Preventive Services Task Force [19]. According to this Task Force, primary care clinicians should provide dental screening, risk assessment and referrals for dental care as part of medical care of their young patients. The approach is based on triaging children according to risk, where only those with current ECC, or those determined to be at high risk for future dental caries are referred to a dentist. This approach is more conservative and realistic than other recommendations that suggest all children should be referred to a dentist by one year of age [20], and is supported by the AAP guidelines [7].

Study variables

Dependent variable

The dependent variable was a binary variable derived from the EFs, defined as whether the physician referred the child to a dentist (yes/ no). Of the total available EF (N=29,528), the referral variable had missing information on 5125 (17.4%) of forms. These 5125 EFs were excluded from the analysis resulting in the analytic sample of 24,403 EFs. We compared the characteristics of children according to whether or not they were excluded because of the missing information on the referral variable. Among those excluded, about 31% (N=1589) also had missing information on the dental caries variable and the physician indicated that the child did not have any signs of decay in 65% (N=3331) of EFs. Of the included EFs (N=24,403), 27.4% (N=6638) had missing information on the dental caries variable, which was imputed using multiple imputation. The process of imputing the dental caries data is described in the next section.

Main explanatory variable at the child-level

At the child-level we hypothesized that the presence of dental caries in the child would be the strongest predictor of being referred to a dentist. This hypothesis is based on the finding that physicians most often consider the presence of ECC or ECC risk in their decision to refer a child to the dentist [12]. On the EFs, the dental caries variable had 11 categories for indicating the number of teeth with decay (no teeth with decay, and increments of two affected teeth from 1-2 to 19-20 teeth). Because most children were identified as not having any decayed teeth, we used a dichotomous indicator in our analyses to capture whether the child had none versus one or more decayed teeth.

Of the 24,403 EFs with non-missing referral variable available for the child's first IMB visit, about 27.4% (N=6638) had missing information on the dental caries variable. We used multiple imputation techniques to impute the missing dental caries data. The analyses presented in this paper collapsed the dental caries variable into a binary indicator of presence or absence of disease as mentioned above. However, for imputing the missing ECC data, we used the original 11-category variable from the EFs with non-missing information on dental caries to allow for flexibility in using this variable in future analyses.

The details of the imputation procedure are described in a technical report [21]. Briefly, to generate the imputed dental caries data we first estimated a random intercepts zero-inflated poisson (ZIP) model using all available observations with non-missing information on dental caries and with the random intercepts capturing between-county variation in dental caries rates. The ZIP model provides a good fit for dental caries data, which commonly displays overdispersion (mean for the count variable is less than its variance) and an excess of zeros [22]. In this model caries at the child level was modeled as a function of the child's age (age in months in linear and quadratic terms), race (Hispanic or not), percent of child's county population 0-17 yrs. of age living in poverty, and the Health Professional Shortage Area (HPSA) for primary care designation for the child's county (whole, partial or not HPSA). The random effects predictions and coefficient estimates from this model were then used to generate predictions for the dental caries variable for children with missing dental caries information. The process was repeated 20 times to generate 20 datasets with complete information on the dental caries variable. All regression results presented in this paper use these 20 datasets with non-missing, possibly imputed, information on the dental caries variable to provide the estimates and standard errors for the regression models.

Main explanatory variables at the practice level

Because pediatric practices have more child patients and likely have a good record-keeping system in place to keep track of all their child patients we anticipated that they would be more likely to refer children to dentists than health departments or family medicine practices. It also is likely that practices that see large numbers of children with ECC during any time period, may take a greater interest in referring children. We therefore hypothesized that ECC at the practice level, over and above individual caries levels, would be positively associated with referrals. A measure of practice-level ECC was constructed by summing the number of children with one or more decayed teeth during the three months prior to the month in which a child's IMB visit occurred to capture the contextual effect of ECC seen at the practice-level.

We hypothesized that referral rates might be lower in practices providing a high volume of IMB services because of the time needed to make referrals. The volume of IMB services at the practice-level was measured using a count of the number of IMB visits that had occurred in the practice from the date when they first started providing IMB services to the day prior to the date of a particular child's IMB visit. Because of the highly skewed distribution of this variable, we used a natural log transformation for it in all our analyses.

Other child and practice-level control variables

Other child- and practice-level control variables included child's age in months, the quarter in which the child's IMB visit occurred during 2001-2002, and the percent of the population in the child's county on the public water system that is fluoridated. All regression models in this analysis include a quadratic (age square) term along with age in months to allow for a non-linear relationship between age and the likelihood of referral. Time is controlled using dichotomous indicators of the quarter of the visit.

Three aggregated variables at the practice level were used to capture the effect of differences in distribution of age, sex, and minority (vs. white) race Medicaid-enrolled children seen across practices during the month in which the child had his or her IMB visit. Three variables were used to measure the availability of general and pediatric dentists in the county where the practice is located and the availability of general dentists in the largest contiguous county (defined based on population size) to the practice county. We also included controls for the number of 0-17 year olds and number of Medicaid-enrolled children per 10,000 population in the practice county.

Lastly, two definitions were explored to capture the degree of urbanization of the practice county based on the rural-urban continuum codes of the US Department of Agriculture [23]. The first definition uses a 7-category variable that categorizes each county according to the population size of its metro area and for non-metro counties, its degree of urbanization and proximity to a metro county. A non-metro county is considered to be adjacent to a metro county if it lies physically adjacent to the metro county and at least 2% of its labor force commutes to the central metro county. There is evidence that children from non-metro counties that are adjacent to a metro county exhibit more tooth decay than children from metro counties, or non-metro counties that are not adjacent to a metro county [24]. Further, caries experience and untreated tooth decay is usually higher among areas with a smaller population, i.e., the non-metro areas. The second definition collapses the 7 continuum codes to compare metro counties to non-metro counties.

Analysis strategy

A two-level hierarchical logit model of children nested within medical practices provided estimates of child, medical practice and county characteristics that influence the likelihood of referral for dental care. Random intercepts at the practice-level allowed the probability of referral to vary across the sample of medical practices. In this model, y_{ij} is the binary dependent variable indicating whether child *i* in practice *j* received a referral for dental care. The model estimates the probability of referral as $Pr\ (y_{ij} = 1)$, where y_{ij} is modeled using a logit link function and assumes that y_{ij} has a Bernoulli distribution conditional upon the random effect. At the child level we model the log odds of referral for each child as a function of a medical practice-specific effect and child-level covariates.

Level - 1 (Child-level) Model……………………………………………………...(1)

$$\begin{aligned}Logit[\Pr(Y_{ij}=1)] = {} & \beta_{0j} + \beta_1(Age_{ij} - Age_{.j}) + \beta_2(Age_{ij} - Age_{.j})^2 + \beta_3(Minority_{ij} - Minority_{.j}) + \\ & \beta_4(Male_{ij} - Male_{.j}) + \beta_5(Caries_{ij} - Caries_{.j}) + \beta_{6-12}(7DummiesForQuarterOfIMBVisit_{ij}) + \\ & \beta_{13-15}(3FluoridationDummyVariables_{ij})\end{aligned}$$

The model at the practice-level similarly models the average log odds of referral for each practice as varying around, via a practice-specific random effect, an overall average log odds of referral adjusting for practice characteristics.

Level - 2 (Medical practice-level) Model…………………………………………..(2)

$$\begin{aligned}\beta_{0j} = {} & \beta_{00} + \beta_{01}(Age_{.j} - MeanAge_{..}) + \beta_{02}(Age_{.j} - MeanAge_{..})^2 + \beta_{03}(<50\%MedicaidMinortiyChildren_{..}) + \\ & \beta_{04}(MeanPctMale_{..}) + \beta_{05}(MeanCaries_{..}) + \beta_{06}(HealthDept_j) + \beta_{07}(Family\Pr actice_j) + \\ & \beta_{08}(Log(\Pr acticeCumulativeIMBvisits_{.j})) + \beta_{09}(\#PediatricDentistsPerAge0to17Pop_j) + \\ & \beta_{010}(\#Gen.DentistsPer10{,}000Pop_j) + \beta_{011}(\#DentistsPer10{,}000Pop.ContiguousCounty_j) + \\ & \beta_{012}(ChildrenAge0to17Per10{,}000Pop_j) + \beta_{013}(\#MedicaidEnrolledChildrenPer10{,}000Pop_j) + \\ & \beta_{014}(NonMetroCountyDummy_j) + u_{0j}\end{aligned}$$

$$u_{0j} \sim N(0, \sigma^2)$$

The variables in the child-level model are centered around the practice mean (group mean centered), and the practice-level means for these variables are reintroduced into the model at the practice-level and centered around overall means to allow separation of the effects of these variables between the two levels of the model. The continuous variables in the practice-level model are centered at the overall mean value of that variable [25].

Because logit is a non-linear model, the marginal effects on the probability scale of the explanatory variables on the dependent variable are not constant for all values of the explanatory variables. Thus, in order to compute the marginal effects for the statistically significant variables we calculated estimates, via simulation, for an average change in the probability [26] of observing the dependent variable given a one or more unit increase in the continuous variable, e.g., age. For dummy variables (e.g., child has ECC or not), the calculation provided an average probability for observing the data e.g., given a change in the child's status from being disease free to having ≥1 tooth with decay. The marginal effect calculations were done twenty times, one for each of the twenty imputed datasets. We present results for the median, and the 25^{th} and 75^{th} percentile of these marginal effects to show the range of marginal effects values across the imputed datasets.

All analyses were conducted using SAS® version 9 (SAS, Cary, NC, USA) and Stata® version 9 (Stata Corp., College Station, TX, USA). The SAS® procedure PROC GLIMMIX was used to estimate the two-level random intercept models using the residual pseudo-likelihood (RSPL) procedure and the dual Quasi-Newton optimization algorithm. The SAS® procedure PROC MIANALYZE was used to obtain average values for the estimates and standard errors across the 20 complete datasets with imputed ECC information.

We estimated the two-level random intercept model with two different approaches for defining the rural/ urban variable using all available observations (N=24,403). The first model included the categorical variable that captures the degree of urbanization of a county based on its proximity to a metro area with a population of 1 million or more [23]. Because results from this model appeared to be driven by the metro or non-metro status of the county, we collapsed the 7 rural-urban continuum codes to compare non-metro counties to metro counties. We consider the latter model with the dichotomous metro vs. non-metro variable to be our preferred model and only present results related to that model in this paper.

It is widely reported that major differences exist in the availability of dental [27] and primary medical care and in the prevalence of dental disease between urban and rural areas [24]. We explored the potential differential effects of variables including, presence of ECC in the child, and the availability of general and pediatric dentists on the likelihood of referral from metro and non-metro counties. These interaction effects were statistically significant (results not shown) and therefore in a second analysis we stratified the data based on the metro or non-metro status of the county where a particular practice is located to explore the differences in likelihood of referrals by a county's urbanization status. All explanatory variables in these stratified models were the same as those included in the overall model that used all available observations.

4.4. Results

Descriptive results for the overall study sample

A total of 24,403 EFs completed during a two-year period (2001 and 2002) from 140 medical practices in 71 counties of NC were included in the overall sample (see Table 1).

The average age of children in the sample was 16 months, with the majority of them belonging to a non-white race. About 5.0% of the sample was identified as having ECC by providers and about 2.8% of the sample was referred to a dentist. The majority of the children were from counties where greater than or equal to 75% of the population on the public water system has access to fluoridated water, followed by 6.8%, 4.1% and 3.7% of children from counties where 50-75%, 25-49% and 0-24% of the population on the public water system has access to fluoridated water, respectively. Majority of the IMB visits occurred in pediatric practices (81%) followed by health departments (13%) and family medicine practices (6%). Overall, medical practices averaged about 52 IMB visits in a month. There were about 4 general dentists per 10,000 population in each of the 71 counties, but only 28 counties had one or more pediatric dentists during the study period, resulting in an average of less than one pediatric dentist per 10,000 population age 0-17 years of age. Overall, more children were seen in medical practices located in metropolitan counties than in non-metropolitan counties.

Descriptive results for the stratified sub-samples

There were 13,492 observations from 60 medical practices in metro counties and 10,911 observations from 80 medical practices in non-metro counties (see Table 1). The average age and race distribution in the two sub-samples was similar to the overall sample. Non-metro counties had only a few more children identified as having ECC by their providers compared to metro counties (5% vs. 4.9%), but had more children who received referrals than in metro counties (3% vs. 2.5%). Metro counties had more areas with greater than or equal to 75% of their population on the public water system receiving fluoridated water than non-metro counties (93.5% vs. 77%). The distribution of observations from health departments, and family physician and pediatric practices was similar to the overall sample. Metro counties had more IMB visits per practice per month than non-metro counties (57.9 vs. 45.5). Non-metro counties had almost half the number of pediatric dentists per 10,000 population age 0-17 years compared to metro counties (.39 vs. .19). The number of Medicaid eligibles (age 0-17 years) was higher in metro counties (667.1) compared to non-metro counties (89.9).

Descriptive results for referrals and ECC

Among children identified as having ECC, only 33% received a referral. Of the total number referred, about 58% (396/680) of children according to the provider had any signs of ECC (see Table 2). A somewhat higher percent of children identified as having ECC were referred from non-metro (33.6%) than metro counties (31.7%). About 62% (211/343) of children who received a referral from metro counties were identified as having ECC by their provider compared to 55% (184/337) of those with a referral from non-metro counties.

Regression results for the overall model

Table 3 presents results for the two-level random intercept models for the likelihood that a child received a referral for dental care. On average within a medical practice, increasing age of child and children with one or more teeth with decay (as identified by the physician) were significantly more likely to be referred than those without any ECC (OR 30.9, 95% CI [25.5, 37.5]). Children with visits to a practice in a month where more than 50% of children seen in the practice were of a minority race had 1.4 times higher odds

(1/exp(–.34)) of being referred for dental care than children who received IMB services in months where less than 50% of children seen in the practice were of a minority race. Increasing numbers of IMB visits in a practice were associated with lower odds of referral of children from within those practices. The likelihood of referral was significantly higher in the presence of a general dentist in a contiguous county to the county where the IMB practice is located. Children seen in practices located in non-metro counties were 1.6 times more likely to be referred than those seen in practices located in metro counties. The random level-2 intercept for variation in referrals across medical practices was not significant in the overall model. Similar results were obtained when all practice-level variables were excluded and the model was estimated with only the child-level variables.

Marginal effects for the overall model

Marginal effects (median, 25th and 75th percentile values) for the statistically significant variables from the overall model are presented in Table 5 under the results for the "Overall sample". Holding other factors constant, a one-month increase in the child's age over the sample average is associated with an increase of nearly 1.7 percentage points in the probability of receiving a referral. The referral probability is almost 22 percentage points higher for children with ≥1 decayed tooth compared to those who are disease free. A ten unit increase in the number of Medicaid eligibles per 10,000 population increases the probability of referral by 3.4 percentage points. The referral probability for children seen in practices located in non-metro counties is .4 percentage points higher than for children seen in medical practices in metro areas. Although the number of IMB visits at the practice level was statistically significant, its marginal effect was small for a 50-unit increase over the sample average (.003 percentage points). The marginal effect for this variable remained similarly small even for a 100- and 150-unit increase in the number of IMB visits over the sample average (results not shown).

Regression results for the stratified analysis

Results of the regression models for the stratified analysis based on whether the county where the medical practice is located is classified as a metro or a non-metro county are presented in Table 4. In both models, increasing age of the child and the presence of one or more teeth with decay were the strongest predictors of being referred to a dentist. The effect of having ECC was, however, stronger in the metro counties where the odds ratio for referral for children with dental decay was 39.7 (95% CI [30.2, 52.2]) compared to 29.1 (95% CI [21.7, 38.9]) for non-metro counties.

Each additional child with decay seen in a practice during a three-month period prior to and including the month of the IMB visit was associated with higher odds of referral (OR=15.0, 95% CI [1.6, 144]) of children from within that practice in metro counties. The availability of pediatric dentists lowered, whereas the availability of general dentists per 10,000 population increased the odds of referral from practices in metro counties. Children seen in a non-metro county practice in a month where more than 50% of children seen in the practice were of a minority race had 1.8 times higher odds (1/exp(–.57)) of being referred for dental care than children who received IMB services in months where less than 50% of children seen in the practice were of a minority race. Children seen in family physician practices in non-metro areas were significantly less likely to be referred. The availability of general dentists in the largest contiguous county to the county where a practice is located increased the odds of referral (OR=1.25, 95% CI [1.11, 1.41]) from practices in non-metro counties.

In metro counties an increase in the number of Medicaid eligibles per 10,000 population had a significant positive effect on referrals, whereas in non-metro counties an increase in this variable was associated with a reduction in the odds of a referral. Increasing numbers of IMB visits in practices in both metro and non-metro counties were associated with lower odds of referral of children from those practices. The random level-2 intercept for variation in referral likelihood across medical practice was not significant in either of the two models. However, when all practice-level variables were excluded and the stratified models were estimated with only the child-level variables, the variance of the random intercept was significant at $P < .05$ in the model for non-metro, but not for metro counties.

Marginal effects for the stratified analysis

Marginal effects for statistically significant variables from the stratified analysis are presented in Table 5 (see columns under stratified analysis by metro and non-metro county). Holding other factors constant, on average, a one month increase in age (over the respective sample averages) is associated with an increase of nearly 3 and 1 percentage points in the probability of receiving a referral in metro and non-metro counties, respectively. Among children with ≥1 decayed teeth the referral probability is almost 22 percentage points higher compared to those without ECC, for children receiving IMB services in practices located both in metro and non-metro counties. For each additional child with ECC (over the average for a practice) in a practice in a metro county, the likelihood of referral increases by 1.9 percentage points. Children in family medicine practices in non-metro counties have a lower probability of referral than pediatric practices by about 1 percentage point. The probability of referral of a child from a medical practice is lower by about 1 percentage point for an additional pediatric dentist in a metro county. A ten-unit increase (over the respective sample averages for metro and non-metro counties) in the number of Medicaid eligibles per 10,000 population in a metro county increases the likelihood of referral by 1 percentage point, but reduces the likelihood of referral in non-metro counties by about .1 percentage points.

4.5. Discussion

The increasing prevalence of Early Childhood Caries (ECC) among preschool age, mainly low-income, children and the rising numbers of children being born into poverty have led to ECC being classified as a silent epidemic in the United States [28]. This problem is further compounded by severe limitations in dental care access for young low-income children who are eligible for public insurance programs such as Medicaid that provide dental coverage, but despite such coverage are unable to achieve optimal oral health. These issues have resulted in a call to expand access to preventive dental care for young children in the medical primary care setting, which they access far more often than a dental office [29]. This concept has wide support in the medical community, and many states have implemented preventive dental programs in the medical setting for their Medicaid-enrolled children. However, several questions remain about physicians' provision of these services, including their ability to detect ECC and make referrals to dentists for children determined to have dental needs.

This study makes several important contributions in this area. This is the first study to combine Medicaid claims for physician delivered preventive dental services with physician-completed oral health risk assessment checklists to evaluate referrals for dental care within a medical model for delivery of preventive dental care to young Medicaid-enrolled children. Patient encounter forms (EFs) acted as a guide for physicians in conducting the oral health risk assessment and provided valuable information on ECC (as reported by the physician) and referral, information that is traditionally not available in claims data. A systematic review of interventions that improve the process of referrals from primary care found that the use of checklists or structured referral sheets at the time of referral is effective in improving the process of identifying patients in need of a referral [30]. Although physicians were not reimbursed for completing the EFs in the NC IMB program, our analyses indicate that most physicians from practices participating in IMB completed EFs for children receiving IMB services [13]. The completion of EFs by physicians increased over time and mirrored the widespread adoption of IMB activities throughout the state in year 2001 and onward [13].

During the training for the IMB program, physicians received education on how to detect ECC and use that information, along with other risk factors such as parent reports about the child's bottle use at bedtime etc, as the basis for referring children to the dentist. For this study, we assessed the appropriateness and predictors of physician referrals to dentists. We assessed the appropriateness of referrals by examining the number of children with ECC who were not referred (under-referral). We were however limited in our ability to assess over-referrals (the children without disease that received a referral) because these children may have received referrals due to physicians' identification of ECC risk factors in the child or there may have been a failure to record existing disease. We were unable to account for other risk factors indicated on the EF because of missing information on these variables for a substantial proportion of our sample.

We found that no referral was provided for the majority of children that physicians identified as having ECC. These results are somewhat similar to the study by Pierce and colleagues (2002) where physicians were tested for their ability to detect dental caries and refer children in need to a dentist following a 2-hour training session. The authors found that physicians identified ECC in 30 out of 258 preschool age children, but provided referrals for 21 of the 30 children. This issue of under-referral was further investigated in a study of self-reported screening, risk assessment and referral practices of 171 pediatric primary care providers [31]. The authors found that providers who report conducting screening and risk assessment very frequently (vs. less frequently or never) were significantly less likely to under-refer infants and toddlers who exhibit signs of decay or were considered to be at high risk for decay. Another study suggests that physicians' poor self-confidence in their ability to detect ECC is a possible explanation for the finding that physicians tend to under-refer [12]. It appears that although physicians are able to identify ECC, they likely need further training to enhance their self-confidence in caries detection and providing the needed referrals to dentists. Further, any attempts to improve under-referrals likely needs to be tied to system level changes that encourage and assist practitioners to provide oral health risk assessment services on a more frequent basis.

We also found about 42% of children who were referred to a dentist at their first IMB visit had no recorded signs of ECC. One possible explanation for this finding is that physicians used the risk assessment questions on the EF to interview parents and perceived the child to be at risk for future ECC, and hence recommended that the child should see a dentist. Pierce et al. (2002) similarly found that physicians provided referrals for some children despite indicating that the child was disease free. It is possible that physicians used other factors such as the child's demographic characteristics or parent-reported bottle-feeding practices to identify children who were at high risk for tooth decay. They also could be using guidelines from the American Academy of Pediatric Dentistry [32] that recommend that all children should see a dentist by one year of age, regardless of risk [7]. Such referrals are of less concern than cases where children with signs of ECC are not referred.

The predictors of physician referrals for dental care, the second component of this study, were evaluated in the context of the IMB training of physician that uses a risk-based model of identifying children with ECC and referring them to a dentist. This assessment of predictors also was informed by previous studies that have identified factors that are likely to encourage physicians to provide dental referrals [11, 12, 33]. Results from the overall analysis indicate that pediatric primary care providers who have received training in oral health risk assessment are strongly influenced by the presence of ECC in their decision to refer a child to a dentist. These results are similar to a previous study of pediatricians and family physicians who were trained to provide preventive dental services in North Carolina [12]. In that study of 169 primary care clinicians, nearly 54% of providers reported that they provide dental referrals for their patients, and a majority (78%) of these providers said that they do so for children who exhibit signs of tooth decay or those considered to be at future risk for decay. This pattern of referral also is closely aligned with the American Academy of Pediatrics guidelines for oral health risk assessment by physicians [7], that recommends considering a child's ECC status in physicians' referral decisions.

Results from the overall model indicate that children seen in medical practices located in a non-metro county are significantly more likely to be referred. In the stratified analysis the effect of having ECC on referral was much larger for children seen in practices located in metro counties (OR=39.7, 95% CI [30.2, 52.2]) than those located in non-metro counties (OR=29.1, 95% CI [21.7, 38.9]). These results are also supported by initial analyses with the full sample that indicated a differential effect of ECC on the likelihood of referral for children seen in practices in metro versus non-metro counties. Although the stratified regression models (similar to the overall model) control for the availability of dental providers, there may be other factors that providers consider in their decision to refer a child to the dentist and these factors may vary by provider location in a metro or non-metro county. For example, the greater distance to a healthcare provider is commonly cited as one reason for lower healthcare utilization rates in rural areas. Travel distances also may be a reason that referrals by providers in non-metro areas are not as strongly influenced by ECC in the child as those in metro areas. It is unclear why the availability of pediatric dentists has a negative association with the likelihood of referral in metro counties, although the size of the effect is not large. One possible reason for this finding is that large metro areas likely have fewer opportunities for social interactions between pediatric dentists and pediatricians or family physicians compared to smaller non-metro regions.

The stratified analysis also indicates that, while controlling for the ECC status of a child, practices in metro counties that see an above average number of children with dental decay over a period of three months are significantly more likely to provide referrals than practices that see only a few children with decay. At least two possible explanations may account for this finding. First, it is possible that increasing numbers of children that providers see with dental decay, increases their self-confidence in detecting disease as suggested by dela Cruz and colleagues [12]. Second, providers that see many children with ECC in their practice may have a heightened sense of awareness of the problem and therefore make an extra effort to conduct oral health risk assessments and provide referrals to dentists for their child patients. Further, children were more likely to receive referrals from medical practices in non-metro counties that in a given month saw more than an average number of Medicaid-enrolled children belonging to a minority race. Results from this study indicate that a high volume of children from this high-risk group when seen in a medical practice increases the probability that children from that practice will receive a referral. We know from the literature that ECC is concentrated among the minority population groups and those covered by public insurance programs [34]. This association may reflect increased provider awareness of the problem of ECC when they see a large number of children with the disease in a short time period.

We found a significant positive association between the availability of general dentists and the likelihood of receiving a referral in metro counties. The availability of a general dentist in the largest contiguous county is important for practices located in non-metro counties, indicating that physicians are aware of problems of limited (or no) availability of dentists in non-metro areas. In 1999, North Carolina ranked 47th in the number of dentists and 36 counties had no dentists providing services to Medicaid recipients [35]. In addition, there is a misdistribution of dentists between the metro and non-metro counties. For example, in 2001 there were 4.6 dentists per 10,000 population in metro counties, but only 2.9 dentists per 10,000 population in the non-metro counties [27]. This report also found that four counties had no dentist, and that during 1996-2005 of the 33 counties that experienced a decline in the number of dentists per 10,000 population, 26 were non-metropolitan counties. It therefore is not surprising that the availability of general dentists in the same county as the medical practice increases the likelihood of referral in metro counties, but for non-metro counties, having a provider in a contiguous county is important in whether a child will be referred or not.

Lastly, the application of multilevel methodology in our analyses allowed us to separate out the influence of child-level variables (for example the presence of tooth decay in a child) from the contextual effect of the amount of dental decay seen at the practice-level. None of our models showed a significant variation in the practice-level likelihood of referral once various factors were controlled, as indicated by the non-significance of the variance of the random intercept. However, in the stratified model for children seen in practices in non-metro counties, the random intercept variance was statistically significant when all practice-level effects were excluded from the model. This finding indicates that the practice-level variables in that model were effective in controlling for the variation in the likelihood of referral across practices. Possible reasons for not finding a similar effect for metro counties are that practices truly do not differ in their provision of referrals or that the overall low numbers of children receiving referrals precluded us from finding a significant effect.

Limitations

One of the most important limitations of this study is its observational design. Although we imputed the missing dental caries data, the study results may still be biased if physicians were more likely to complete EFs for children who exhibited signs of decay. At the time of conducting this study we had access to complete claims and EF data only for

2001 and 2002. A larger sample size may have allowed us to explore the effects of oral health risk assessment activities during a period when there was widespread adoption of IMB activities across the state. We also had a large number of EFs with missing information on the variable that indicated whether or not the child was referred to a dentist. It is possible that for many of these cases providers did not complete this information because no referral was provided. In that case our estimates of the proportion of children referred would be an over-estimate of the true referral rate. However, referral estimates from our study (2.8% for overall sample) are lower than those from the study by Pierce and colleagues [11] where 10.5% of children received referrals and makes us confident of our results.

Conclusion and policy considerations

The presence of ECC is influential in primary care physicians' decision to refer children for dental care, and is in accordance with the American Academy of Pediatrics' recommendation that all high-risk children should receive a referral to a dentist. However, the low rate of referrals for children identified as having ECC in our study indicates that much work needs to be done to increase the likelihood that all children with ECC receive the same recommendation (referral) to see a dentist by their medical provider. Within a risk-based framework for providing preventive dental care in medical offices, the issue of appropriateness of referrals (under- and over-referral) is important. Results from this study confirm previous findings that physicians tend to under-refer [11]. We based our conclusion of under-referral on the number of children with ECC. Future studies need to examine under-referrals by physicians while also accounting for the children they identify as being at high risk for ECC.

The presence of a dental provider (either in the same county for metro areas or a contiguous county for non-metro counties) was an important medical practice-level variable in physicians' decision to refer a child. Interestingly, the volume of IMB visits at the practice level had very little influence on the likelihood of a referral from a particular practice. However, there likely are other factors that we were unable to control for in our analyses that might influence these under-referrals. These include physicians' reluctance to over-burden parents, a belief that the disease was not serious enough to necessitate a referral or their poor self-confidence in the ECC they detected in a particular child [11]. Thus, future research needs to more closely examine physicians' referral decisions to further understand why they fail to refer all children that they identify as having ECC.

There is little evidence for what the optimal referral rate should be and how much we can expect to increase it in the presence of ECC or risk factors for ECC. A recent systematic review examined the effectiveness of various interventions to improve outpatient referrals from the primary care to a secondary care setting [30]. The authors concluded that the use of structured referral sheets or checklists is effective in improving the appropriateness of outpatient referrals. In this study, the one-page physician-completed encounter form can be considered a checklist that acted as a guide for the medical provider in conducting oral health risk assessment and providing a referral, if needed. Future research therefore needs to examine whether factors other than the use of a checklist are likely to positively influence under-referrals to dentists by physicians.

Similarly, the issue of over-referral, is important and likely controversial from a policy standpoint because of the differing recommendations from the American Academies of Pediatrics and of Pediatric Dentistry for the age at which children should see a dentist. In an ideal situation all children should receive referrals, have the opportunity to visit a dentist and establish a usual source of dental care (a dental home) by one year of age. However, given the limited resources and shortage of providers, referring every child to the dentist is likely not an effective solution to addressing ECC in a high-risk population. Programs that encourage pediatric primary care practitioners to provide screening and referral services will need to ensure that systems are in place that assist and encourage the practitioners to provide these services in an efficient manner where children most in need of care receive priority in terms of being referred to a dentist.

Attempts to improve the process of referrals from the primary medical to the dental setting also will need to consider the unique challenges and opportunities that urban and rural counties offer and how these might influence whether a child is referred to a dentist or not. These differences between metro and non-metro counties also suggest that preventive dental programs in the medical setting might need to be tailored to a particular medical practice setting, rather than implementing a generic program for all types of settings. For example, for practices located in metro counties, the number of children with ECC seen in the previous three months to a child's preventive dental visit positively influenced the likelihood of referral. ECC at the practice level, above and beyond that seen among children in the practice, likely makes providers more sensitive to the problem of ECC and motivates them to provide referrals. Future research needs to examine whether provider awareness of ECC at the practice level makes them less likely to under-refer. If so, then one possible intervention directed at medical practices would be to increase medical practitioners' awareness of the magnitude of the problem of ECC in their and other medical practices. This study contributes to our knowledge of physicians' referral practices and factors that influence their delivery of oral health risk assessment and referral services for preschool age low-income children with dental care needs. Future research needs to examine the effectiveness of physician referrals in promoting children's access to and use of dental care.

Table 4.1. Descriptive statistics for the analytic sample

	Overall sample N=24,403 children in 140 medical practices			Metro county sample N=13,492 children in 60 medical practices			Non-metro county sample N=10,911 children in 80 medical practices		
VARIABLE DESCRIPTION	**Mean or %**	**S.D**	**Range**	**Mean or %**	**S.D.**	**Range**	**Mean or %**	**S.D.**	**Range**
Child-level variables									
Child's age in months at IMB visit	15.91	7.12	6-36	15.92	7.03	6-36	15.91	7.23	6-36
Child is male (vs. Female)	52.0	.5		52.0	.5	0-1	51.0	.5	0-1
Child's race									
Minority (vs. white)	61.0	.49	0-1	63.0	.48	0-1	59.0	.49	0-1
Child has ECC (as indicated by the medical provider)	4.98	2.17	0-1	4.94	2.17	0-1	5.02	2.18	0-1
Child was referred to a dentist	2.79	1.65	0-1	2.54	1.57	0-1	3.09	1.73	0-1
Water fluoridation in child's county of residence. Percent of county population on the Public Water System (PWS) receiving fluoridated water			0-1			0-1			0-1
0-24%	3.72	.19		1.5	.12		6.0	.25	
25-49%	4.11	.19		.01	.10		8.0	.27	
50-74%	6.84	.25		5.0	.22		9.0	.28	
≥ 75%	85.33	.36		93.5	.12		77.0	.42	
Provider-level variables									
Type of setting for IMB services			0-1			0-1			0-1
Health department	14.0	.34		13.0	.33		15.0	.35	
Family medicine practice	6.0	.23		7.0	.26		4.0	.19	
Pediatric practice	80.0	.39		80.0	.4		81.0	.39	

* Classification based on county where IMB practice is located
Observations restricted to 2001 through 2002

Table 4.1. Descriptive statistics for the analytic sample (contd.)

	Overall sample N=24,403 children in 140 medical practices			Metro county sample N=13,492 children in 60 medical practices			Non-metro county sample N=10,911 children in 80 medical practices		
VARIABLE DESCRIPTION	**Mean or %**	**S.D**	**Range**	**Mean or %**	**S.D.**	**Range**	**Mean or %**	**S.D.**	**Range**
Provider-level variables (contd.)									
Volume of IMB visits in practice									
Total IMB visits per practice/ month	52.37	65.19	.08-1190	57.93	68.99	.08-1190	45.49	59.44	.08-527
<50% of Medicaid-enrolled children are of a minority race (vs. ≥ 50%) in a month	31.8	.47	0-1	29.4	.45	0-1	34.9	.48	0-1
Dental market variables									
# Pediatric dentists per 10,000 population age 0-17 years*	.31	.43	0-2.9	.39	.41	0-2.08	.19	.42	0-2.9
# General dentists per 10,000 population*	3.53	1.55	0-12.1	3.83	1.72	1-12.1	3.16	1.21	0-5.5
# Medicaid eligibles per 10,000 population*	767.1	248.8	27.5-1359	667.1	13.55	344-1276	89.9	299.5	27.5-1359
Age 0-17 population per 10,000*	3.58	3.4	.16-17.6	5.06	3.88	.83-17.64	1.76	.94	.16-3.58
*Rural/ urban county classification where medical practice is located, constructed using the Rural-Urban Continuum Code**				.55	.5	0-1	.45	.5	0-1
Counties in metro areas	.55	.5	0-1						

* Classification based on county where IMB practice is located
Observations restricted to 2001 through 2002

Table 4.2. Referrals by ECC and metro/ non-metro status of county where medical practice is located

County where practice is located	Provider identified Early Childhood Caries (Average sample across 20 imputed datasets)		Referred to a dentist	
			Number	Percent
Overall sample	ECC	1214	396	32.58
	No ECC	23,189	284	1.23
	Total	24,403	680	2.79
Metro county	ECC	667	211	31.73
	No ECC	12,825	132	.97
	Total	13,492	343	2.54
Non-metro county	ECC	548	184	33.61
	No ECC	10,363	153	1.48
	Total	10,911	337	3.09

Table 4.3. Two-level random intercept model for the likelihood of referral for dental care

	Overall Model				
Variable description	**β**	**S.E.**	**Odds ratio**	**95% CI**	
Child-level characteristics					
Constant	-4.35^{***}	.62			
Child's age in months at IMB visit	$.184^{***}$	.033	1.20^{***}	1.13	1.28
Child's age^2	$-.0026^{**}$	.0008	$.997^{**}$	.996	.999
Child is of minority race (vs. white)	.0946	.0904	1.09	.92	1.31
Child is male (vs. female)	.08	.11	1.08	.87	1.34
≥1 teeth with decay (vs. none)	3.431^{***}	.098	30.91^{***}	25.49	37.49
Quarter in which IMB visit occurred (vs. Oct'02-Dec'02)					
Jan'01-Mar'01	.57	.38	1.77	.84	3.72
Apr'01-Jun'01	–.20	.21	.82	.54	1.24
Jul'01-Sep'01	–.26	.19	.77	.53	1.11
Oct'01-Dec'01	.06	.17	1.06	.76	1.49
Jan'02-Mar'02	$.52^{**}$	.15	1.68^{**}	1.24	2.26
Apr'02-Jun'02	.19	.16	1.21	.89	1.64
Jul'02-Sep'02	–.18	.16	.84	.61	1.15
% Population on the Public Water System in child's county receiving fluoridated water (vs. ≥ 75%)					
0-24%	–.02	.23	.98	.62	1.55
25-49%	–.37	.24	.69	.43	1.11
50-74%	$-.61^{*}$	.21	$.54^{*}$	.36	.82
Aggregated practice-level variables					
Average age of Medicaid enrolled children seen in practice	$.059^{*}$	.019	1.06^{*}	1.02	1.10
Average male Medicaid-enrolled children in the practice in month of IMB visit (vs. female)	–.51	.37	.60	.29	1.24
<50% of Medicaid-enrolled children are of a minority race (vs. ≥ 50%) in a month	$-.34^{*}$	.12	$.71^{*}$	.56	.90
Average number of children with ≥1 tooth with decay seen in practice 3 months prior to IMB visit (vs. no teeth with decay)	1.119	1.029	3.07	.41	23.08

*** Significant at $P \leq .001$, ** Significant at $P \leq .01$, * Significant at $P \leq .05$.

Table 4.3. Two-level random intercept model for the likelihood of referral for dental care (contd.)

	Overall Model				
Variable description	**β**	**S.E.**	**Odds ratio**	**95% CI**	
Practice characteristics					
Type of setting where IMB services were provided (vs. pediatric practice)					
Health department	.27	.15	1.31	.98	1.75
Family medicine practice	–.144	.204	.87	.58	1.29
Total IMB visits per practice from date of 1st IMB claim through month of current IMB visit.					
Log (IMB visits)	–.192***	.044	.83***	.76	.89
Practice County characteristics					
# Pediatric dentists/ 10,000 pop. age 0-17 years	–.23	.14	.79	.60	1.05
# General dentists per 10,000 pop.	.075	.048	1.08	.98	1.18
# General dentists/ 10,000 pop in largest contiguous county to practice	.074*	.037	1.076*	1.002	1.156
Age 0-17 pop. in county/ 10,000 population	.020	.017	1.02	.99	1.06
# Medicaid eligibles/ 10,000 pop.	–.00081*	.00031	.99*	.99	.99
Practice is in non-metro (vs. metro) area	.47**	.13	1.59**	1.24	2.07
Level-2 (practice-level) random intercept variance	.0117	.0082			

*** Significant at $P \leq .001$, ** Significant at $P \leq .01$, * Significant at $P \leq .05$.

Table 4.4. Two-level random intercept models for the likelihood of referral for dental care – stratified analysis by metro and non-metro county

	Stratified model for practices in metro counties (N = 13,492 from 60 practices)					Stratified model for practices in non-metro counties (N=10,911 from 80 practices)				
Variable description	**β**	**S.E.**	**Odds ratio**	**95% CI**		**β**	**S.E.**	**Odds ratio**	**95% CI**	
Child-level characteristics										
Constant	-7.293^{***}	1.089				-2.57^{*}	.89			
Child's age in months at IMB visit	$.275^{***}$	.049	1.32^{**}	1.19	1.45	$.108^{*}$	.046	1.12^{*}	1.02	1.22
Child's age^2	$-.0044^{***}$	.0011	$.996^{***}$	.994	.998	–.0010	.0011	.99	.99	1.00
Child is of minority race (vs. white)	.06	.13	1.06	.83	1.37	.16	.13	1.17	.91	1.51
Child is male (vs. female)	.01	.16	1.01	.74	1.36	.13	.16	1.14	.84	1.55
≥1 teeth with decay (vs. none)	3.68^{***}	.14	39.67^{**}	30.17	52.16	3.37^{***}	.15	29.08^{***}	21.70	38.98
Quarter in which IMB visit occurred (vs. Oct'02-Dec'02)										
Jan'01-Mar'01	1.29^{*}	.54	3.64^{*}	1.26	1.52	–.07	.52	.94	.34	2.61
Apr'01-Jun'01	–.26	.34	.77	.39	1.51	–.33	.29	.72	.41	1.26
Jul'01-Sep'01	.12	.26	1.12	.68	1.86	$-.98^{**}$	.29	$.38^{**}$	.21	.67
Oct'01-Dec'01	.21	.24	1.24	.78	1.96	–.48	.27	.62	.37	1.05
Jan'02-Mar'02	.34	.22	1.41	.91	2.18	$.49^{*}$	.22	1.64^{*}	1.06	2.53
Apr'02-Jun'02	–.29	.24	.75	.47	1.20	$.4^{*}$	.22	1.59^{*}	1.04	2.43
Jul'02-Sep'02	–.08	.24	.93	.58	1.47	$-.49^{*}$	.24	$.62^{*}$	.38	.99
% Population on the Public Water System in child's county receiving fluoridated water (vs. ≥ 75%)										
0-24%	–.19	.66	.83	.23	3.02	–.09	.26	.91	.54	1.52
25-49%	.22	.56	1.24	.41	3.76	–.35	.28	.70	.41	1.22
50-74%	$-.78^{*}$	.36	$.46^{*}$	.23	.93	$-.89^{*}$	.29	$.41^{*}$	.23	.73

*** Significant at $P \leq .001$, ** Significant at $P \leq .01$, * Significant at $P \leq .05$.

Table 4.4. Two-level random intercept models for the likelihood of referral for dental care – stratified by metro and non-metro county (contd.)

Variable description	Stratified model for practices in metro counties (N = 13,492 from 60 practices) β	S.E.	Odds ratio	95% CI		Stratified model for practices in non-metro counties (N=10,911 from 80 practices) β	S.E.	Odds ratio	95% CI	
Practice-level characteristics										
Aggregated practice-level variables										
Average age of Medicaid enrolled children seen in practice	.067*	.033	1.069*	1.002	1.141	.046	.026	1.05	.99	1.10
Average male Medicaid-enrolled children in the practice in month of IMB visit (vs. female)	.06	.59	1.06	.33	3.39	–.59	.49	.55	.21	1.43
Less than 50% minority Medicaid enrolled children in practice in month of child's IMB visit (vs. >50%)	.11	.18	1.12	.78	1.59	–.57*	.18	.57*	.40	.80
Average number of children with ≥1 tooth with decay seen in practice 3 months prior to IMB visit (vs. no teeth with decay)	2.71*	1.16	15.03*	1.56	144.0	–2.69	1.78	.0682	.0021	2.26
Practice characteristics										
Type of setting where IMB services were provided (vs. pediatric practice)										
Health department	.24	.23	1.28	.82	1.99	.10	.22	1.11	.72	1.70
Family physician practice	–.14	.27	.87	.51	1.49	–1.33*	.42	.27*	.12	.60
Total IMB visits per practice from date of 1st IMB claim through month of current IMB visit.										
Log (IMB visits)	–.181*	.061	.83*	.74	.94	–.24**	.069	.79**	.69	.91

*** Significant at $P \leq .001$, ** Significant at $P \leq .01$, * Significant at $P \leq .05$.

Table 4.4. Two-level random intercept models for the likelihood of referral for dental care – stratified by metro and non-metro county (contd.)

	Stratified model for practices in metro counties (N = 13,492 from 60 practices)					Stratified model for practices in non-metro counties (N=10,911 from 80 practices)				
Variable description	**β**	**S.E.**	**Odds ratio**	**95% CI**		**β**	**S.E.**	**Odds ratio**	**95% CI**	
Practice County characteristics										
# Pediatric dentists per 10,000 population age 0-17 years	–.95*	.35	.39*	.19	.77	.01	.16	1.01	.74	1.39
# General dentists per 10,000 population in practice county	.369***	.088	1.45***	1.22	1.72	–.060	.087	.94	.79	1.12
# General dentists per 10,000 pop in largest contiguous county	.025	.051	1.03	.93	1.13	.221**	.062	1.25**	1.11	1.41
Age 0-17 pop. in county per 10,000 population	.018	.019	1.02	.98	1.06	–.15	.11	.86	.69	1.06
# Medicaid eligibles per 10,000 pop.	.0016*	.0007	1.0016*	1.0002	1.003	–.0011*	.0005	.998*	.998	.999
Level-2 (practice-level) random intercept variance	.005	.012				.023	.011			

*** Significant at $P \leq .001$, ** Significant at $P \leq .01$, * Significant at $P \leq .05$.

Table 4.5. Marginal effects for explanatory variables in the two-level random intercept models for the likelihood of referral for dental care

	Overall sample*			Stratified analysis by metro & non–metro county: Practices in Metro Counties#			Stratified analysis by metro & non–metro county: Practices in Non–metro Counties$		
Variables	**Median**	**25th Percentile**	**75th Percentile**	**Median**	**25th Percentile**	**75th Percentile**	**Median**	**25th Percentile**	**75th Percentile**
Child's age (1 month increase over sample average)	.017	–.012	.034	.027	–.0221	.0269	.0082	–.0036	.015
≥ 1 tooth with decay	.22	.13	.34	.22	.12	.37	.22	.13	.34
Child lives in county where 50–74% of pop. has access to fluoridated water (vs. ≥ 75%)	–.0042	–.0082	–.0024	–.0038	–.0085	–.0019	–.0062	–.012	–.0032
Avg. age of Medicaid enrolled children in practice (1 unit increase over average)	.00053	.00029	.00103	.00046	.00022	.00046			
<50% of Medicaid–enrolled children in a month in the practice are of a minority race (vs. ≥ 50%)	–.0029	–.0055	–.0016				–.0052	–.0103	–.0026

Notes: * Model estimates are presented in Table 3 under "Overall model". #Model estimates are presented in Table 4 under "Stratified model for practices in metro counties". $ Model estimates are presented in Table 4 under "Stratified model for practices in non-metro counties."

Table 4.5. Marginal effects for explanatory variables in the two-level random intercept models for the likelihood of referral for dental care (contd.)

				Stratified analysis by metro & non–metro county					
	Overall sample*			Practices in Metro Counties#			Practices in Non–metro Counties$		
Variables	**Median**	**25th Percentile**	**75th Percentile**	**Median**	**25th Percentile**	**75th Percentile**	**Median**	**25th Percentile**	**75th Percentile**
Avg. children with ≥1 decayed tooth seen in practice 3 months prior to IMB visit (vs. no decayed teeth) (1 unit increase over average)				.019	.009	.041			
Family medicine (vs. pediatrics)							–.0075	–.015	–.0037
Total IMB visits/ practice from date of 1st claim through month of current visit (50 unit increase over sample average)	–.000031	–.00006	–.00002	–.000018	–.00004	–.00002	–.000041	–.000081	–.000021
# Pediatric dentists/10,000 population age 0-17 years (1 unit increase over sample average)				–.0065	–.014	–.0032			

Notes: * Model estimates are presented in Table 3 under "Overall model". #Model estimates are presented in Table 4 under "Stratified model for practices in metro counties". $ Model estimates are presented in Table 4 under "Stratified model for practices in non-metro counties."

Table 4.5. Marginal effects for explanatory variables in the two-level random intercept models for the likelihood of referral for dental care (contd.)

				Stratified analysis by metro & non–metro county					
	Overall sample*			Practices in Metro Counties#			Practices in Non–metro Counties$		
Variables	**Median**	**25th Percentile**	**75th Percentile**	**Median**	**25th Percentile**	**75th Percentile**	**Median**	**25th Percentile**	**75th Percentile**
# General dentists/10,000 population in county where practice is located (one unit increase over sample average)				.00017	.000082	.00037			
# Dentists/10,000 population in largest contiguous county to practice county (one unit increase over sample average)	.00018	.0001	.00035				.0015	.0029	.00074
# Medicaid eligibles/10,000 population (10 unit increase over sample average)	.034	.019	.067	.0074	.0036	.016	–.0011	–.0021	–.00055
Practice is located in a non-metro (vs. metro) area	.0043	.0024	.0085	-	-	-	-	-	-

Notes: * Model estimates are presented in Table 3 under "Overall model". #Model estimates are presented in Table 4 under "Stratified model for practices in metro counties". $ Model estimates are presented in Table 4 under "Stratified model for practices in non-metro counties."

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5. THE EFFECT OF PHYSICIAN REFERRALS ON USE OF DENTAL CARE BY MEDICAID-ENROLLED PRESCHOOL AGE CHILDREN

5.1. Abstract

Objective: To examine whether physician referrals can facilitate use of dental care as part of a program ("Into the Mouths of Babes", IMB) that expands access to preventive oral health services in the pediatric primary care setting for Medicaid-enrolled preschool age children in North Carolina (NC).

Data sources: NC Medicaid claims for 2001 and 2002 merged with dental risk assessment forms completed by participating medical providers.

Study design: Observational study using survival analysis techniques to examine the effect of receiving a referral for dental care on children's use of dental services.

Principal findings: Of 24,403 children in the study, 854 had a dental visit during the two-year study period. The proportion of children who received a referral was higher among those with documented Early Childhood Caries (ECC) (32.9%) compared to those without indication of disease (1.2%). Of those identified as having ECC, the proportion of children with a dental visit was larger for those who received a referral (35.6%) compared to those who were not referred (12%). In the Cox model for time to use of dental care, for those with ECC who received a referral the hazard for a dental visit was 7.9 compared to those who had no ECC or referrals. Increasing age of child, the availability of a general dentist in the county and having a dental visit prior to the child's first IMB visit were all associated with shorter times to a dental visit.

Conclusions: Overall, physicians' referrals helped facilitate use of dental care but physicians have a tendency to under-refer and their referrals are only effective in promoting a small proportion of children to use dental services. Future research needs to examine system- and process-level strategies to improve the effectiveness of physicians' referral practices and outcomes.

Key words: Medicaid, pediatric primary care, Early Childhood Caries (ECC), oral health risk assessment, referral, dental use

5.2 Introduction

Access to dental care for preschool age children is a serious problem, especially among children covered by public insurance programs such as Medicaid [1]. Many low-income children have access to full insurance coverage, including dental care, through Medicaid. However, they experience the greatest amount of dental disease, have the highest unmet need for dental care, and the lowest rates of dental care utilization of children of any socioeconomic group [2]. Traditionally, efforts to reduce their most common disease, Early Childhood Caries (ECC), have included parent education and counseling regarding infant feeding practices, training dental professionals to care for infants and young children, and increasing dental reimbursement rates for Medicaid and the State Children's Health Insurance Program (SCHIP), two publicly-funded programs that provide dental insurance for low-income children [3, 4]. However, these efforts have had only limited success in reducing the burden of ECC [5].

The provision of oral health screening and risk assessment services during well-child visits in medical offices has been suggested as a way to link dental and medical services during early childhood [6]. These screenings are important, particularly for low-income, preschool age children because they can facilitate early detection of dental disease in young children who frequently have medical visits but rarely make dental visits [7]. These interventions are supported by professional guidelines, which recommend that physicians should screen children for dental disease during routine medical visits [8, 9]. Training materials for non-dental healthcare providers on oral health risk assessment have been developed by a number of organizations including the American Academy of Pediatrics (AAP) and the American Academy of Pediatric Dentistry (AAPD) [10, 11]. Additionally, a number of programs have been implemented to train physicians and other non-dental personnel to provide preventive oral health services [12]. Yet these programs are recent innovations, so evaluations are rare and scientific evidence regarding physicians' activities in this area is limited [13].

Physician guidelines for oral health risk assessment provided by the AAP and by Medicaid as part of the Early and Periodic Screening, Diagnostic, and Treatment (EPSDT) Program place emphasis on physician referrals to a dentist as a way of establishing a dental home for the child. The AAP guidelines emphasize that referrals should occur as early as when the child is six months of age if he or she is considered to be at high risk for ECC, and by three years of age for all children [8]. Under EPSDT guidelines, direct referrals to a dentist are required based on the periodicity schedule set by the state, usually when the child is three years of age, and at other times as medically necessary [14, 15].

Most physicians self-report that they are likely to conduct screenings for dental risk factors and obvious dental disease [16, 17]. Studies also suggest that primary care providers can recognize obvious disease with a reasonable degree of accuracy. Pierce and colleagues conducted a study of physician's ability to conduct oral health screenings and provide dental referrals in a private pediatric group practice in North Carolina that serves a large number of Medicaid-enrolled children [18]. Physicians received 2 hours of education on infant oral health and were then asked to examine study participants (258 preschool age children) for signs of ECC and make referral recommendations. The primary care providers achieved a sensitivity of .76 (95% CI: .71-.81) and a specificity of .95 (95% CI: .93-.98) in identifying children with ECC when compared to the gold standard, a pediatric dentist, in the study. In another study, Ismail and colleagues [17] surveyed a representative sample of family physicians and pediatricians in the U.S. The majority of the physicians (91% of pediatricians; 77% of family physicians) reported that they frequently screen young children for gross signs of tooth decay. When presented with case scenarios of two children with mild and severe dental disease, indicating a low and a high-risk child respectively, more physicians recommended that the high-risk child be referred compared to the low-risk child.

In a cross-sectional study of physician referral behavior, greater than 90% of providers reported referring infants and toddlers for dental care [19]. Of those providers, almost 80% reported that they refer based on obvious disease or for cases where they believe that the child might have the beginning signs of decay. However, despite this high level of self-reported referral activity, at least one study that documented physicians' detection of ECC and whether or not they provided referrals indicates that physicians tend to under-refer children with ECC [18]. In that study, only 70% of those identified as having ECC were provided with a referral. Thus self-reported estimates of referrals provided by physicians may over-estimate the referrals they actually provide. This issue of under-referral is important because fewer children receiving needed referrals is likely to translate into fewer children using dental care.

We know little about the effectiveness of physician referrals in facilitating use of dental care for children receiving these referrals. A recent systematic review [13] of the role of primary care physicians' role in preventing dental caries in preschool age children identified only one study that examined the effectiveness of non-dental health professionals' referrals to dentists for children 6 months to 5 years of age in the Women, Infants and Children (WIC) Supplemental Food Program [20]. The authors found no difference in dental visit rates between children who did and did not receive a referral in a multivariate analysis that controlled for child's age, maternal age, household size, presence of dental insurance for the child and the mother's perception of the child's dental needs. The low rates of dental use among Medicaid-enrolled children receiving EPSDT services including dental referrals also points to the less than optimal effectiveness of physician referrals in promoting use of dental care in this population [21].

A key goal of programs that encourage primary care medical providers to conduct oral health risk assessments and referrals for follow-up dental care is to ensure that children identified as having ECC or those considered to be at elevated risk are able to gain access to a dentist. Although medical providers are committed to the oral health of their preschool age patients, little empirical evidence is available about the effectiveness of physician-delivered referrals in facilitating visits to dental offices. The current study addresses this gap by analyzing the effectiveness of referrals to dentists provided by physicians on use of dental care among preschool age children from low-income families.

5.3. Methods

Overview of study design and analysis

This is a cohort study of Medicaid-enrolled children who received preventive dental services as part of a comprehensive program being offered since 2000 in primary care medical offices across North Carolina for children birth through 35 months of age. We combined NC Medicaid claims data with patient oral health risk assessment records completed by physicians and other information sources to examine the effect of receiving a physician referral on children's use of dental care. While the IMB program is intended ultimately to reduce the need for dental treatment through prevention services such as fluoride vanish applications and parent oral health counseling, the increased attention given to dental health by physicians should lead to more timely referrals for treatment of existing disease. We therefore used survival analysis techniques to examine whether, after controlling for ECC, children who received a physician referral were able to see a dentist earlier than children who did not receive a referral.

In January 2000 the NC Medicaid program began reimbursing pediatric and family physician practices and health departments across the state for preventive dental care for Medicaid-enrolled children under the "Into the Mouths of Babes" (IMB) program [22]. According to NC Medicaid policy in effect during the period of this study, participating medical providers could submit claims for preventive dental services provided during well-visits or other office visits for a maximum of 6 visits, separated by at least 90 days, before the child's third birthday. To receive any reimbursement from NC Medicaid for a visit in which IMB services are provided, practitioners are required to provide three services: (1) screening the child for dental disease and referral to a dentist if needed, (2) topical fluoride application on the child's teeth, and (3) parent education about preventive oral health care practices for their child. The oral health risk assessment training provided to practitioners as part of IMB uses the American Academy of Pediatrics guidelines that recommend referring to the dentist before three years of age only children with ECC or those at high risk for disease [8].

Data Sources

This study included children who received preventive dental services at 6 through 36 months of age during 2001 and 2002 in the NC IMB program. Data for this study came from three sources, each of which is described in the following sections.

1. Medicaid enrollment and claims files

Medicaid claims and enrollment data for all children enrolled in Medicaid during the study period were obtained from the NC Division of Medical Assistance (DMA), the agency responsible for administering the Medicaid program in NC. Claims data provided detailed information about claims submitted by physicians for IMB services, and claims for dental treatment submitted by dentists participating in the NC Medicaid program. The enrollment files provided information on the child's date of birth, race, sex and county of residence. A third file containing information about medical providers participating in the NC Medicaid program for the study period was used to identify characteristics of the practice where a medical visit occurred. Henceforth, these three datasets (enrollment, claims and provider file) will be referred to as the "Medicaid data."

2. Patient encounter forms (EFs)

During the demonstration and early implementation phase of the NC IMB program (years 2001 through 2004) physicians completed encounter forms (EFs) for each IMB visit in addition to submitting claims for reimbursement and voluntarily submitted them to the project office for data entry. Physicians were trained in the use of the EF in guiding patient care decisions. The physicians provided additional information on the EFs about the child's dental caries and risk status, parental reports about child feeding and oral hygiene practices, an IMB visit indicator (i.e., the sequence number of the current visit of a total of 6 possible visits), and whether the physician referred the child to a dentist. EFs were not sent to the project office after 2004 when the funded demonstration project ended.

Based on our analysis of the completeness of EFs compared to claims, we found that physicians were most likely to complete EFs at the child's first IMB visit. We therefore restricted the analysis for this study to the child's EF completed at his or her first IMB visit. Data from the EFs and claims were merged using Medicaid identification numbers, with a 90% match between encounter forms and claims [23]. The EFs were matched to claims data from 2001 through June 2003 to track subsequent visits to the dentist. Electronic records of EFs for children who had their first IMB visit during from January 2001 through December 2002 (N=29,528) were available for this study.

3. County-level data

The Area Resource File (ARF) was used to obtain demographic and economic characteristics (e.g., per capita income) of the 100 counties in NC [24]. County-level information on the number of dentists was obtained from the North Carolina Health Professionals Data System (NCHPDS), which is available through the University of North Carolina's Cecil G. Sheps Center for Health Services Research. Evidence from at least one study indicates that the county can be considered a dental service market area [25]. In addition, a verified list of pediatric dentists in each NC county was obtained from the Department of Pediatric Dentistry at UNC-CH. The NC Community-Level Information on Kids (CLIKS) database was used to obtain county-level data on number of children (age 0-17 years) enrolled in Medicaid in every NC county for 2001 [26]. County-level water fluoridation status was obtained from the Oral Health Section of the NC Department of Health and Human Services [27].

Conceptual framework

The framework for our analysis draws upon work by Shortell who proposed a model for physician referral behavior [28]. Shortell's model suggests that referral is a function of patient (e.g., type and severity of illness and demographics), provider (e.g., type, workload) and community-level variables (e.g., rural vs. urban). We also draw on a systematic review of physicians' role in preventing dental disease among children conducted for the U.S. Preventive Services Task Force [13]. Results of this review suggest that primary care clinicians should provide dental screening, risk assessment and referral for dental care as part of medical care of their young patients. The approach is based on triaging children according to risk, where only those with current dental disease, or those determined to be at high risk for future dental decay are referred to a dentist. This approach is more conservative and realistic than other recommendations that suggest all children should be referred to a dentist by one year of age [29], and is supported by the guidelines from the American Academy of Pediatrics [8].

At least one study suggests that in a scenario where there exists excess demand for dental care and a fixed workforce capacity, adopting a risk-based approach would prevent crowding out of low-revenue generating Medicaid-insured children by private-pay patients[30]. A key goal of the risk-based approach is to facilitate access to dental care for children with the most immediate dental care needs. An evaluation of the success of this approach involves the assessment of both the effectiveness and appropriateness of the referral. The current study focuses on the effectiveness of physician referrals in facilitating dental care use for Medicaid-enrolled children of preschool age.

Study variables

<u>Dependent variable</u>

The dependent variable in this study was the time in days from the child's first IMB visit to his or her first dental visit as evidenced by the presence of a dental claim for a visit for any reason that was reimbursed by the NC Medicaid program.

<u>Main explanatory variable</u>

The main explanatory variable was a binary variable derived from the EFs, defined as whether the physician referred the child to a dentist (yes/ no). Of the total available EFs (N=29,528), the referral variable had missing information on 5125 (17.4%) of forms. These 5125 EFs were excluded from the analysis resulting in the analytic sample of 24,403 EFs. We compared the characteristics of children who were excluded because of the missing information on the referral variable. Among those excluded, about 31% (N=1589) also had missing information on the dental caries variable and the physician indicated that the child did not have any signs of decay in 65% (N=3331) of EFs.

<u>Dental caries and other child-level control variables</u>

At the child-level we hypothesized that the presence of ECC in the child would be the strongest predictor of using dental care. This hypothesis is based on the finding that physicians most often consider the presence of dental decay or dental disease risk in their decision to refer a child [19]. Further, children with ECC that is causing pain are likely to make a dental visit even in the absence of a referral. We therefore control for the presence of ECC and also examine its interaction with whether the child received a referral or not in modeling the length of time to a dental visit. On the EFs, the dental caries variable had 11 categories for the indicating the number of teeth with decay (no teeth, and increments of 2 affected teeth from 1-2 teeth to 19-20 teeth). Because most children were identified as not having any decayed teeth, we used a dichotomous indicator in our analyses to capture whether the child had none versus one or more decayed teeth.

Of the EFs available for the child's first IMB visit (N=24,403), about 27.4% (N=6638) had missing information on the dental caries variable. In a previous analysis, we examined the child- and practice-level predictors of the likelihood that a child would receive a physician referral for dental care. Because that analysis needed to account for the hierarchy of children clustered within medical practices, we developed a model to impute the missing dental caries data taking into account this hierarchy. Recently, Carpenter and Goldstein (2004) suggested that when data are hierarchical in nature and the proposed analyses will use hierarchical modeling methods, the imputation model also should account for this hierarchy [31].

This process of imputing the dental caries data is described in detail in a separate technical report [32]. Briefly, to generate the imputed dental caries data we first estimated a county random effects zero-inflated poisson (ZIP) model using all available observations with non-missing information on dental caries. The ZIP model provides a good fit for dental caries data, which commonly display overdispersion (in the sense that the mean for the count variable is less than its variance) and an excess of zeros [33]. In this model caries at the child level was modeled as a function of the child's age (age in months, and two quadratic age terms), race (Hispanic or not), percent of child's county population 0-17 years of age living in poverty, and the Health Professional Shortage Area (HPSA) for primary care designation for the child's county of residence (whole, partial or not HPSA). The random effects and coefficients estimated from this model were then used to generate predictions for the dental caries variable for children with missing dental caries status. The process was repeated 20 times to generate 20 datasets with complete information on the dental caries variable. All regression results presented in this paper use these 20 datasets with non-missing information on the dental caries variable to provide the estimates and standard errors.

Other child-level control variables included the child's age in months (centered at the sample mean of 16 months), whether the child had any preventive and/ or treatment related dental visits prior to his or her first IMB visit (which may indicate that he or she has an established dental home), and the percent of the population in the child's county on the public water system that has access to fluoridated water. In order to control for the effect of the timing of the child's first IMB visit, we included a variable that controlled for the month during 2001-2002 in which the IMB visit occurred.

Practice-level control variables

At the practice level, two variables were used to measure the availability of general and pediatric dentists in the county where the IMB practice was located. The average number of general dentists per 10,000 county population for the study sample was 3.5 in 2001, which is very close to the average of 4 dentists per 10,000 population in 2000 in NC [34]. For ease of interpretation of the hazard ratio we dichotomized this variable to compare counties with average or above average number of general dentists to those counties that have a below average general dentist to population ratio. We anticipated that providers with a high volume of IMB visits might be less likely to find the time to refer children for dental care than other practices. The volume of IMB services at the practice-level was measured using a count of the number of IMB visits that had occurred in the practice from the date when they first started providing IMB services through the date of a particular child's IMB visit. We also controlled for the proportion of the 0-17 year-old population in the practice county that was enrolled in Medicaid. Lastly, the degree of urbanization of the practice county was based on the rural-urban continuum codes of the U.S. Department of Agriculture [35]. A set of six dummy variables was created to capture the degree of rurality of a county based on its proximity to a metro area with a population of 1 million or more.

Analysis strategy

This study included 24,403 children 6 through 36 months of age who received their first IMB visit during 2001 and 2002 in one of 140 medical practices in North Carolina. We used survival analysis to model the time to use of dental care subsequent to the child's first IMB visit in the medical office. Our main hypothesis was that controlling for ECC in the child, a physician referral is likely to facilitate use of dental care, and therefore children who receive a referral should be able to see a dentist earlier than those who do not receive a referral from the physician. Thus, the failure event (a 0/1 variable) was identified by the presence of a dental claim for the child, and the censoring variable was defined as the child's second IMB visit or 6 months from the date of the first IMB visit, whichever occurred earlier. We chose to use the presence of a dental claim rather than evidence of a treatment or preventive visit as the failure event because the focus of this study was on the effectiveness of the physician referral in promoting access to a dentist's office, not on the appropriateness or type of care needed. A window of 6 months was chosen because evidence indicates that children enrolled in public insurance programs such as Medicaid can face a long waiting period between making an appointment and being able to see the dentist [36].

We estimated Kaplan-Meier survival curves for time to use of dental care by referral status (yes or no) and ECC status (ECC or no ECC). The log rank test was used to examine whether the presence of ECC in combination with (and without) a referral influences children's use of dental care by testing for the equality of the survivor functions for those who did and did not receive a referral in each of the two groups with and without ECC [37]. For multivariate analysis, child and medical practice characteristics were entered into a Cox proportional hazards model for correlates of time to use of dental care.

The Cox model included interaction terms for the presence of decayed teeth and whether the child was referred to a dentist or not to allow us to examine the possible differential effects of various combinations of these two variables on the hazard for a dental visit. We also included an interaction term between the dichotomous variable that captures whether the county has a below average number of general dentists or not, and whether the child received a referral from his or physician. In our analyses this interaction was not significant and is therefore not included in the model presented in this paper.

We evaluated two variables (child's age in months and the number of IMB visits that had occurred in the practice) for the most appropriate functional form for inclusion in the Cox model. To determine the functional form we first generated martingale residuals obtained from fitting a null model (i.e., a Cox model without covariates). Both these variables were then plotted against the residuals using a lowess smoother. The plot for the child's age was not linear at higher values (greater than 24 months). A quadratic function of age yielded a better fit for the data. Similarly, for the cumulative number of IMB visits a log transformation yielded a more linear result. We estimated robust standard errors for the Cox model to account for clustering of observations at the practice-level. Lastly, a test based on Schoenfeld residuals was used to assess whether the estimated model violated the proportional hazards assumption.

All analyses were conducted using SAS® version 9 (SAS, Cary, NC, USA) and Stata® version 9 (Stata Corp., College Station, TX, USA). The SAS® procedure PROC MIANALYZE was used to obtain average values for the estimates and standard errors across the 20 complete datasets with imputed ECC information.

5.4. Results

Child and provider characteristics of the study sample

The study sample included data for 24,403 children who had their first IMB visit in 2001 or 2002 at 140 medical practices from 71 of the 100 North Carolina counties. Table 1 includes descriptive statistics for the study sample. The average age of children in the sample was 16 months, and white, black and Hispanic children represented 39%, 38% and 15% of the sample, respectively. Most children in the sample were living in an area where the public water system is fluoridated. A majority of the IMB visits occurred in pediatric offices, followed by health departments and family physician practices, and medical practices in the study sample averaged about 50 IMB visits per month. On average, there were about 4 general dentists in each of the 71 counties, but only 28 of the counties had one or more pediatric dentists during the study period. Overall, more children were seen in medical practices located in metropolitan counties than in non-metropolitan counties.

Descriptive results for the presence of dental caries, referral and use of dental care

Table 2 provides a summary of the total number of individuals with a dental claim and those without a dental claim (i.e., censored observations). Of the total 24,403 children in the sample, 854 had evidence of a dental claim being submitted to Medicaid for reimbursement and the remaining 23,459 were censored at or before six months from the date of their first IMB visit. Sixty four percent (255/396) of observations were censored among those who received a referral and had ECC compared to 88% (250/284) among those who had no ECC but were referred.

Figure 5.1 provides a decision tree for the percent of children with and without physician-identified ECC who received a referral, and consequently used dental care. Across the 20 imputed datasets, an average of about 5% of children had one or more teeth with decay. The proportion of children who received a referral was greater among those with caries (32.9%) compared to those without any caries (1.2%). Of those identified as having ECC, the proportion of children with a dental visit was larger for those who received a referral (35.6%) compared to those who were not referred (12%). Among children who had no physician-detected signs of tooth decay, almost 12% of those who were referred visited a dentist compared to 2.5% of children who were not referred for dental care.

Results of the survival analysis for time to use of dental care

The Kaplan-Meier survival curves for time to use of dental care by referral status and the presence or absence of one or more decayed teeth (ECC) are presented in Figure 5.2. The log rank test used to test the equality of the survivor functions for those who did and did not receive a referral in each of the two groups (with and without ECC) rejected the null hypothesis (P-value $\leq .001$) indicating that children in both groups, those with and without ECC, have shorter time to use of dental care if they received a referral compared to those who were not referred.

Table 3 presents the estimates from the Cox proportional hazards model for correlates of time to use of dental care. In this model, increasing age of the child was significantly related to the hazard for a dental visit. The coefficients on the age and age-squared variables indicate an increasing effect of age on the hazard for a dental visit, however, the rate of this increase slows down with increasing age of the child across the entire range of the age variable. For children who had one or more decayed teeth and received a dental referral, the hazard for a dental visit was 7.9 times the hazard for those without ECC who also were not referred (see Table 4 for calculation of the hazard ratios for the interaction effect). Among children with no ECC, those who were referred had a hazard for a dental visit of 3.4, and the hazard for children with ECC, but no referral was 3.2 (both representing a 76% chance of making a dental visit earlier compared to a child with no ECC and no referral).

The type of medical practice where the IMB visit occurred, the number of IMB visits in the practice or the number of pediatric dentists per 10,000 population aged 0-17 years did not affect the hazard for a dental visit. Counties with an average or greater number of general dentists (compared to counties with below average numbers of general dentists) had an increased risk for a dental visit by 27% ($1/\exp(-.236) = 1.27$). Having had a dental treatment or preventive visit prior to the child's first IMB visit significantly increased the hazard for a dental visit subsequent to the first IMB visit. Lastly, children seen in practices located in counties classified as metro areas with a population of 250,000 to 1 million (38% higher hazard) and counties in non-metro areas with an urban population greater than 20,000 not adjacent to a metro area (59% higher hazard) had a higher hazard for a dental visit compared to metropolitan counties with a population of 1 million or more. The test based on Schoenfeld residuals provided no evidence that the proportional hazards assumption was violated.

5.5. Discussion

Early Childhood Caries (ECC) remains an issue of serious concern in the United States, especially for preschool age children from low-income families. Because pediatricians and family physicians have frequent contact with young children, promising models for delivery of preventive pediatric oral health care in the primary medical setting have been implemented in many states. These programs ultimately aim to reduce the need for dental treatment through prevention. However, in the short-term, the increased focus on oral health by primary care providers and the training they receive is also expected to identify children with ECC who have dental treatment needs and to facilitate their use of needed dental care. This study is among the first to examine whether physicians' referrals for ECC facilitate Medicaid-enrolled preschool age children's use of dental care.

The primary finding from this study is that physicians trained to provide oral health screening, risk assessment and referral services as part of the NC IMB program achieved some success in facilitating use of dental care for children with dental needs. The survival curves for time to use of dental care indicate that the combination of having ECC and receiving a dental referral improves the child's chances of seeing a dentist more than any other combination of ECC and referral status of that child. These results are confirmed by the Cox regression model, where the chances of an early dental visit are highest in the presence of ECC and a referral. Interestingly, having a referral in the absence of ECC slightly increases the chances of dental visit compared to children with ECC but no referral. Thus, it also appears that to a small extent, the referral itself has an effect of promoting use of care, irrespective of whether the child has ECC or not.

In a previous study we found that having ECC was a strong predictor of being referred to a dentist [38], and the same data were used for the current study. In that study, the probability of referral was 22 percentage points higher for children with one or more decayed teeth (as identified by the physician) compared to children with no decayed teeth. However, the majority of children with ECC (67%) were not referred in that study, and as seen in the current study only a minority of those referred (36%) actually made a dental visit. Thus, physicians both, under-refer and their referrals do not result in dental visits for all children they recommend for a dental visit. Previous studies have linked factors such as physician self-confidence in detecting ECC with the likelihood that they will refer a child to the dentist [19]. High self-confidence likely also may play a role in the effectiveness of the referral, but we were unable to account for this variable in our analyses. We did control for the volume of IMB visits occurring at a practice, which may to a certain extent be correlated with physicians' self confidence because it is likely that providing a higher number of preventive oral health services may improve physicians' confidence in providing these services. However, this variable was not significantly related to whether a child would have a dental visit or not in our analyses. This analysis also does not control for parental factors that are likely to influence whether children who received referrals made dental visits or not.

As stated earlier, a majority of children who had been identified as having ECC and received referrals did not visit the dentist. These under-referrals, wherein only 33% of children with one or more decayed teeth were referred to a dentist, ultimately influence the small proportion of children who actually made a dental visit. Hence, the success of any program that aims to train physicians as facilitators of children's use of dental services will depend upon improving physicians' ability to engage in providing referrals that result in realized access to dental care for children who received those referrals. Further, results from this study suggest that although some children with signs of ECC will make a dental visit irrespective of whether they receive a referral or not, for the majority, a referral increases the chances for a dental visit. This finding is true for both children with and without ECC. In this study we were limited in not having detailed process information about the referrals that children received. For example, we do not know whether instances of referrals where the physician contacted a dentist via telephone were the most effective. And if one surmises that physician busyness prevented more frequent contact between the physician and the dentist, this could possibly be one reason why the majority of children (64%) did not make a dental visit despite having ECC and receiving a referral. Thus, future work needs to examine the nature of the referral itself to identify system and process characteristics that are likely to enhance the quality of the referral.

When examining the issue of physician referrals for dental care, it is important to consider both the appropriateness and the effectiveness of referrals in facilitating use of dental care for children. However, we were unable to closely examine the issue of appropriateness because of limited information on dental caries risk other than physician-identified ECC status of the child. Nevertheless, the finding that even among children with no ECC, 1.2% were referred and of those almost 12% received dental care indicates that physician referrals are somewhat effective in facilitating dental use. We are however unable to know whether the 12% of children who used dental care had ECC and were wrongly identified by the physician as not having ECC, or they had other risk factors which put them in the high-risk category. In either case, from a policy perspective this could be considered a programmatic success because, in the first case, the child was able to get the care they needed despite the physician not being able to identify their disease. In the second case, we would assume that the physician was able to use a risk-based approach to helping children get the care they needed.

Given the importance of the referral, the process of how this referral is handled at the physicians' end can be an important point of intervention for improving the overall referral process. In addition to physicians' self-confidence in detecting ECC, previous research on physician referral behavior specific to dental care suggests that the level of difficulty involved in arranging a referral for a child is likely to influence physicians' referral decision, which is likely to influence the outcome of the referral itself [19]. System and process changes such as the use of case managers that help parents make the dental appointment and follow-up with reminders are likely to aid with the issue of realized access. In addition to physician characteristics, patient factors also will need to be considered in such an intervention. For example a recent study indicates that low parental literacy is associated with worse asthma care of children, including a greater incidence of emergency room visits and hospitalizations [39]. Thus an intervention that aims to improve the referral process might entail an assessment of the quality of the interaction between the physician and the parent, to improve that process. There is growing evidence that health literacy and patient-physician communication can play an important role in patient outcomes [40] and it is conceivable that the quality of the interaction between the physician and the parent might influence the parent's ability or motivation to seek dental care for their child. Improved communication may also help address logistical issues such as the high frequency of broken appointments, a common reason given by dentists for not accepting Medicaid-insured patients.

Interestingly, other variables that were important in predicting the time to use of dental care also are variables that we found to predict the likelihood that a child will receive a dental referral in a previous study [38]. These variables included increasing age of the child, availability of general dentists in the case of metro counties and the availability of general dentists in a contiguous county in the case of non-metro counties. Thus, having a general dentist available not only makes it likely that the child will receive a referral, but it also makes it likely that the child will be able to obtain the care he or she needs. These findings taken together make a strong case for increasing the interaction between primary care physicians and general dentists in the community if we are to successfully reduce the problem of ECC. It also raises the issue of the important role of the availability of dental providers, especially those willing to provide care to children enrolled in Medicaid, which likely needs to be addressed by a program that aims to expand access to dental care for children.

We found that the availability of a general dentist facilitates use of dental services. However, the number of pediatric dentists did not affect children's use of dental care. The majority of counties in NC do not have a pediatric dentist, whereas most counties have at least one general dentist [34]. Thus, from a policy perspective one will have to look to general dentists in most communities as the first point of contact for primary care physicians involved in oral health risk assessment and referrals. This also means that a more concerted effort will have to be made to train and encourage general dentists to become comfortable with seeing preschool age children in their practices.

Findings from our study also lend support to the importance of a dental home. We found that controlling for ECC and referral status, children who had previously accessed dental care were able to get care more easily the second time compared to children who had never visited a dentist The majority of the visits for these children who had a dental visit prior to their first IMB visit were for preventive care. It is not possible for us to know whether the dental visit was self-initiated by the parent or was the result of a recommendation from a physician or other healthcare provider. Nevertheless, we do see evidence that a previous dental visit facilitates access to a repeat dental visit.

The early establishment of a dental home, a place for a child to get regular, coordinated, comprehensive and culturally sensitive care, is widely advocated as a way to improve children's oral health [41]. Preliminary evidence from at least one study indicates that access to early oral health screening promotes the future use of preventive dental care and lowers dental care related costs. The authors of that study found that Medicaid-enrolled preschool age children who had an early preventive dental visit were more likely to subsequently use preventive dental services and have lower dental treatment costs [42]. The current study provides further evidence that children with a prior contact with the dental care system gain the benefit of that contact even after controlling for other facilitating factors such as a physician's referral for dental care.

A cautionary note related to this finding however is that in the current study we were only able to track dental care utilization for children that was paid for using Medicaid funds. Thus, it is possible that some children who appear not to have had any dental use in our data might actually have used care, but their parents paid out of pocket for that care during spells of disenrollment from the Medicaid program. However, it is likely that for the majority of children at this young age parents have a strong incentive to keep their child enrolled in Medicaid because of the coverage of immunization and other well- and sick-child care. Further, dental care utilization among this age group is low and strongly influenced by insurance coverage, hence our findings likely do not underestimate dental visits by a great extent for these children.

A key issue in screening and referral programs is that professional recommendations for the age for the first dental visit are inconsistent. The American Academy of Pediatric Dentistry (AAPD) and the American Dental Association (ADA) recommend that all children be referred to a dentist by one year of age. In contrast, the American Academy of Pediatrics (AAP) recommends that dental referrals be made only for those children up to 3 years of age who have dental disease or are at elevated risk for disease. These two approaches were evaluated for their effects on dental care use and outcomes for 1- to 3-year-old Medicaid-insured children [30]. The authors report that with excess demand for dental care and fixed workforce capacity, the AAPD/ADA guidelines would increase untreated tooth decay among low-income children because private-pay patients would crowd out low-revenue generating Medicaid-insured children. Results from that study also suggest that adherence to AAP guidelines will likely ensure that children are triaged into the dental delivery system based on risk, that the system will not be over-loaded, and that young children in most need of dental care will be able to receive it.

Study limitations

We have already noted one limitation regarding our inability to explore in detail the nature of the referral and whether a more structured referral process (for example, the use of case managers) is more effective in gaining access to dental care for a child than a referral where the physician's office furnishes the parent with the name and contact information for a local dentist. This study used data from the demonstration phase of the NC IMB program, a time when physicians participating in the program likely were in the process of developing their oral health risk assessment skills and becoming comfortable with providing IMB services. Further, patient encounter forms were only available for a subset of children who received IMB services, as evidenced by the higher number of claims than EFs. There is some indication from a previous study that physicians have a tendency to complete EFs for children who have ECC or other risk factors [38]. But we were unable to account for the extent to which this would bias our analyses.

Although AAP and Medicaid's EPSDT guidelines emphasize that referrals for children need to consider both current dental disease and children who are considered to be at risk for ECC, we were only able to account for the former in our analyses. This is a limitation of our analysis because risk assessment information on the EFs are incomplete and we are unable to tell if cases where the physician indicated that the child did not have ECC, but still provided a referral represent over-referral or appropriate referral because the child was determined to be at risk for ECC.

As indicated before, the referral variable was missing for 17.4% (N=5125) of EFs. These EFs were excluded from the analysis. Of these 5125 EFs, the physician had indicated that the child did not have any signs of decay on 65% (N=3331) of the EFs. However, based on the data used for this study, we know that 12% of children without ECC received a referral. Thus, our exclusion of EFs with missing referral information may lead to an under-estimate of the number of children referred. It also is possible that for many of these cases providers did not complete this information because no referral was provided. In that case our estimates of the proportion of children referred would be an over-estimate of the true referral rate. Lastly, although we control for the availability of general and pediatric dentists, they do not account for whether dental providers in the county are willing to see Medicaid-enrolled children.

Conclusion

Early Childhood Caries (ECC) continues to be an issue of concern among young children and is further worsened by the numerous barriers that prevent them from obtaining the dental care they need. The pediatric primary care setting offers an opportune setting for intervening on this issue because children access care far more often in the primary medical than the dental setting. There is a high level of awareness about ECC among primary care practitioners and many guidelines and programs are actively engaging them in bridging the gap between the medical and dental care settings for young children. Evidence from the current study indicates that physician referrals can facilitate use of dental care by children receiving the referrals. However, physicians tend to under-refer and their referrals result in dental visits for only a small proportion of the children who need to see a dentist. In such a scenario, recommendations that emphasize that all children should receive a referral are likely to have little success in promoting children's use of dental services.

Given our limited resources, program successes are more likely to occur with an effort that focuses on training pediatric primary care providers to identify children most in need of dental care and in developing systems and processes that are likely to enable them to help these children in gaining access to needed treatment services [43]. Recognizing that ECC is a problem of the entire community can help to build the bridge between the pediatric primary medical and dental setting for young low-income children in need of dental services. Multifaceted interventions that encourage the involvement of physicians, parents, dentists and others in the community to build an organized system of oral health risk assessment, referral and dental care will be needed if we are to gain success in addressing the problem of Early Childhood Caries.

Table 5.1. Descriptive statistics for the study sample

VARIABLE DESCRIPTION	MEAN OR %	S.D	RANGE
Child–level variables			
Child's age in months at IMB visit	15.91	7.12	6–36
Child is male (vs. Female) (%)	52.0	.5	
Child's race (%)			0–1
American Indian	4.44	.21	
Asian	.85	.09	
Black	37.55	.48	
Hispanic	15.17	.36	
Other	2.93	.17	
White	39.05	.49	
Quarter in which first IMB visit occurred (%)			0–1
Jan–Mar 2001 (Q1)	1.16	.11	
Apr–Jun 2001 (Q2)	8.66	.28	
Jul–Sep 2001 (Q3)	12.42	.33	
Oct–Dec 2001 (Q4)	13.72	.34	
Jan–Mar 2002 (Q1)	14.99	.36	
Apr–Jun 2002 (Q2)	15.29	.36	
Jul–Sep 2002 (Q3)	16.81	.37	
Oct–Dec 2002 (Q4)	16.95	.38	
Child had a dental visit prior to the first IMB visit (vs. Not) (%)			0–1
Percent of county population on the Public Water System (PWS) receiving fluoridated water in child's county of residence (%)			0–1
0–24%	3.72	.19	
25–49%	4.11	.19	
50–74%	6.84	.25	
≥ 75%	85.33	.36	
Provider–level variables			
Type of setting for IMB services (%)			0–1
Health department	14.0	.34	
Family physician practice	6.0	.23	
Pediatric practice	80.0	.39	
Total IMB visits per practice/ month	52.37	65.19	.08–1190
Dental market variables			
# Pediatric dentists per 10,000 population age 0–17 years	.31	.43	0–2.9
# General dentists per 10,000 population	3.53	1.55	0–12.1

Total observations = 24,403

Table 5.1. Descriptive statistics for the study sample, contd.

VARIABLE DESCRIPTION	MEAN OR %	S.D	RANGE
# Medicaid eligibles per age 0–17 population per 10,000	3076.22	788.19	1626.50–5003.43
***Rural/ urban county classification where medical practice is located, constructed using the Rural–Urban Continuum Code* (%)**			0–1
METRO COUNTIES			
Central or fringe counties of metro areas of 1 million pop or more	9.79	.21	
Counties in metro areas of 250,000 – 1,000,000 pop	25.68	.44	
Counties in metro areas of < 250,000 pop	19.82	.39	
NONMETRO COUNTIES			
Urban pop. of ≥20,000 adjacent to a metro area	17.06	.38	
Urban pop. of ≥20,000 not adjacent to a metro area	3.61	.19	
Urban or rural pop. of ≤19,999, adjacent to a metro area	14.32	.35	
Urban or rural pop of ≤19,999, not adjacent to a metro area	9.72	.29	

Total observations = 24,403

Table 5.2. Summary of number of censored and uncensored values stratified by caries and referral status

No ECC (as indicated by medical provider)				
Referral	**Total obs.**	**# Events**	**# Censored**	**% Censored**
No	22, 915	582	22,333	97.46
Yes	284	34	250	88.03
Sub–total	*23,199*	*616*	*22,583*	*97.34*
ECC present				
Referral	**Total obs.**	**# Events**	**# Censored**	**% Censored**
No	808	97	711	88.0
Yes	396	141	255	64.39
Sub–total	*1204*	*238*	*966*	*80.23*
Total	**24,403**	**854**	**23,549**	

Event – Presence of (first) dental claim for a child
Censoring variable – Second IMB visit or 6 months from date of first IMB visit, whichever occurred earlier

Table 5.3. Cox proportional hazard model for time to dental visit following the child's first IMB visit

Variable	Estimate	Robust Std. Error	Hazard Ratio	95% Confidence Interval		*P*–value
Child's age in months at IMB visit	.1142	.011	1.12	1.10	1.14	<.0001
Child's age^2	–.00194	.00091	.998	.997	.999	.0006
≥1 teeth with decay (vs. none)	1.15	.21	3.15	2.51	3.95	<.0001
Child was referred to a dentist	1.21	.32	3.36	2.29	4.91	<.0001
Interaction of caries * referral	–.29	.38	.75	.48	1.16	.1929
Child is male (vs. female)	.109	.092	1.12	.98	1.28	.1121
Child's race (vs. white)						
American Indian	.16	.66	1.17	.78	1.77	.4442
Asian	–.12	.66	.89	.42	1.89	.7651
Black	–.16	.22	.85	.72	1.00	.056
Hispanic	–.01	.25	.99	.81	1.23	.9619
Other	–.01	.29	.99	.69	1.41	.9492
% Population on the Public Water System in child's county receiving fluoridated water (vs. ≥ 75%)						
0–24%	–.64	.50	.53	.33	.84	.0066
25–49%	.09	.48	1.09	.78	1.56	.5971
50–74%	.05	.51	1.05	.78	1.42	.733
Setting where IMB services were provided (vs. pediatric practice)						
Health department	–.22	.45	.80	.63	1.02	.076
Family physician practice	–.13	.64	.88	.63	1.22	.4299
Total IMB visits per practice from date of 1st IMB claim through month of current IMB visit.						
Log (IMB visits)	–.06	.15	.94	.88	1.00	.0611
# Pediatric dentists/ 10,000 pop. age 0–17 years	–.04	.42	.96	.79	1.17	.7068
< Average # General dentists per 10,000 pop. (vs. ≥ Average)	–.24	.48	.79	.65	.96	.0161

Model controls for month in which IMB visit occurred.
Total observations = 24,403

Table 5.3. Cox proportional hazard model for time to dental visit following the child's first IMB visit, contd.

Variable	Estimate	Robust Std. Error	Hazard Ratio	95% Confidence Interval		*P*–value
Child had a dental visit prior to first IMB visit	2.34	1.12	10.38	6.68	16.15	<.0001
# Medicaid eligibles/ 10,000 age 0–17 population in county	–.0002	.0039	.99	.99	1.00	.429
Rural–Urban Continuum Code for practice county (vs. metro areas of ≥1 million pop)						
METROPOLITAN COUNTIES						
Counties in metro areas of 250,000 – 1,000,000 pop	.32	.66	1.38	1.04	1.84	.0269
Counties in metro area of < 250,000 pop	.12	.69	1.13	.82	1.56	.4607
Urban population of ≥20,000 adjacent to a metro area	–.09	.79	.91	.62	1.34	.6338
NON–METROPOLITAN COUNTIES						
Urban pop of ≥20,000 not adjacent to a metro area	.46	.99	1.59	1.06	2.39	.026
Urban/ rural pop of ≤19,999, adjacent to a metro area	–.24	.69	.79	.55	1.13	.1965
Urban / rural pop of ≤19,999, not adjacent to a metro area	.27	.81	1.31	.87	1.96	.193

Model controls for month in which IMB visit occurred.
Total observations = 24,403

Table 5.4. Hazard ratios for the interaction of ECC and referral from the Cox model for time to use of dental care

	Referral	
ECC	**Yes**	**No**
Yes	exp(1.1.5 + 1.21 – .29) = 7.92	exp(1.15) = 3.16
No	exp(1.21) = 3.35	exp(0)=1

Figure 5.1. Decision tree for presence of physician-identified tooth decay, referral and use of dental care

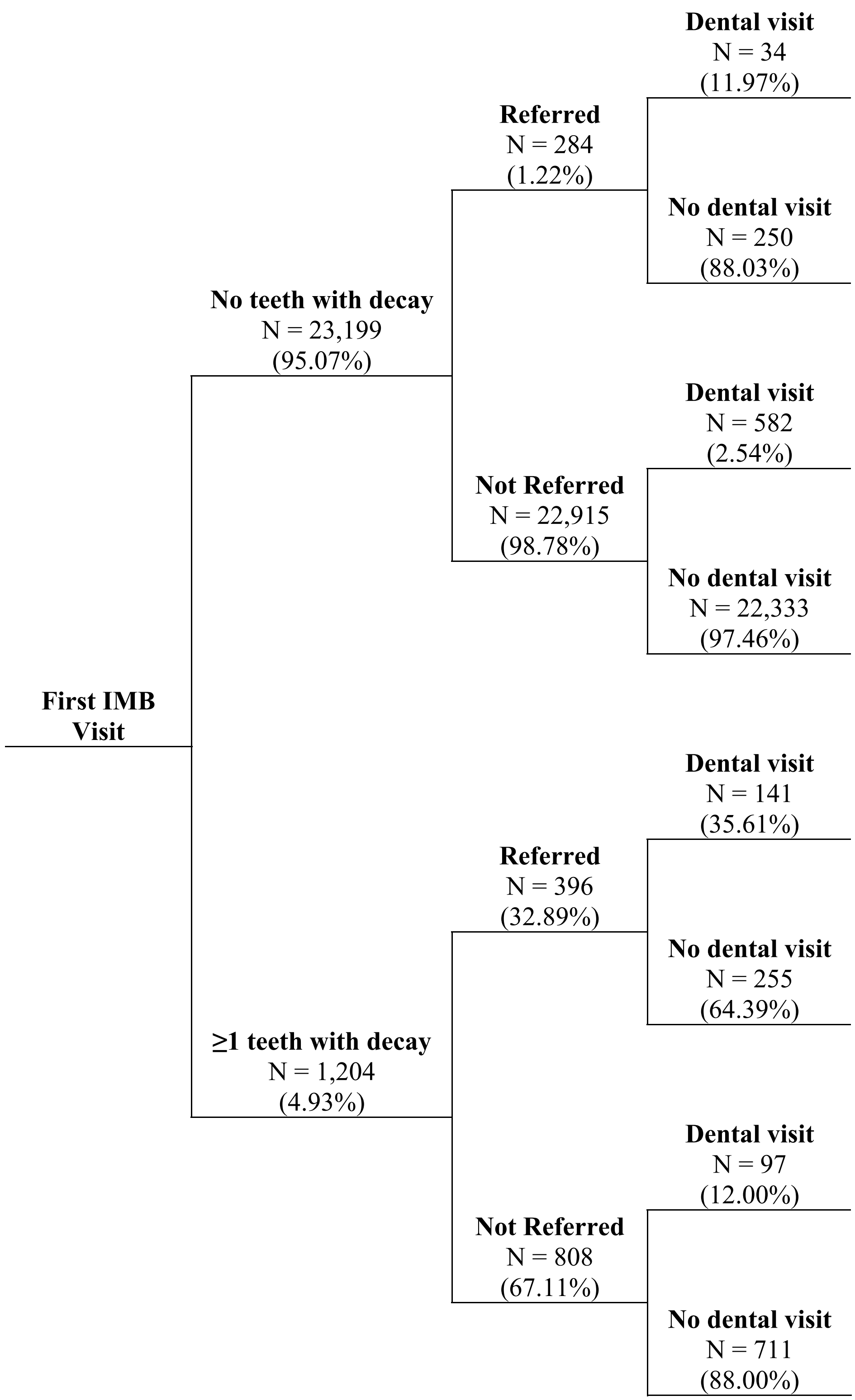
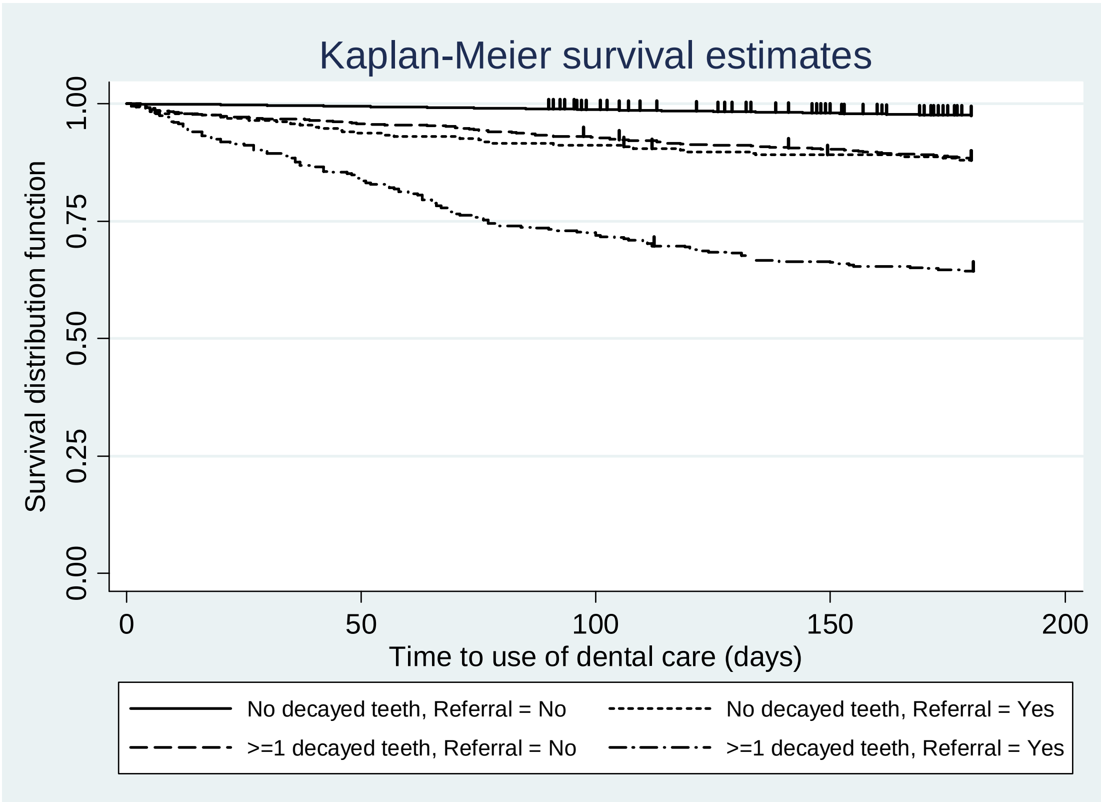


Figure 5.2. Survival curves for time to use of dental care stratified by tooth decay and referral status



** The hash marks on the survival curves represent one or more censored observations*

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6. THE EFFECT OF PROVIDER PARTICIPATION IN A MEDICAL OFFICE-BASED PREVENTIVE DENTAL PROGRAM ON CHILDREN'S ACCESS TO DENTAL CARE

6.1 Abstract

Objective: Into the Mouths of Babes (IMB), offered in North Carolina since 2000, is an innovative program that expands access to preventive oral health services for Medicaid-enrolled preschool age children. This study examines whether primary care medical practices participating in IMB facilitate access to dental care for children receiving well-child care in those practices compared to non-participating practices.

Data source: NC Medicaid claims for 2004 through 2006 for children born on or after July 1, 2003.

Study design: We first identify and classify medical practices into three groups (Well Child Visit only, high volume IMB and low volume IMB practices) based on the average number of IMB visits per Well Child Visit (WCV) provided by the practices. Within each of the three groups, we identify children born on or after July 1, 2003 who were enrolled in the NC Medicaid program during 2004-2006, for a total of 167,358 children across the three groups. We compare time to use of dental care from the child's first WCV for the three practice groups using a piecewise exponential survival model.

Principal findings: Of 1,192 medical practices included in the study, 914 were WCV only, 215 were low volume IMB and 63 were classified as high volume IMB practices. Overall, 16,634 (9.9%) of the 167,358 children in the study sample had at least one dental visit during the study period. Children seen for well-child care in high volume IMB practices had significantly longer time to a dental visit compared to children with WCVs in non-IMB participating practices.

Conclusions: Children seen for well-child care in practices not participating in IMB practices visited dentists sooner than those seen in high volume IMB practices. Results are consistent with the hypothesis that the preventive effect of IMB is larger than the referral effect. Further, the referral effect is not detectable in this study when the referral status of each child is unknown.

Key words: Medicaid, pediatric primary care, Early Childhood Caries (ECC), referral, dental use

6.2. Introduction

Tooth decay among preschool children, known as Early Childhood Caries (ECC), is recognized as the most common preventable chronic disease affecting this age group [1]. Although rates of decay are low at very young ages, they tend to increase rapidly with age. For example, ECC rates are reported to be 1-2% in one year olds [2], but 40% of children entering kindergarten in North Carolina already have experienced decay [3]. Children from low-income families and minorities bear the major burden of disease and ECC can manifest itself in epidemic proportions in this population group. For example, one study of 3- to 5-year-old children enrolled in the Maryland Head Start program reported an ECC prevalence as high as 62% among its enrollees [4]. ECC has tangible negative health effects that prevent children from achieving optimal health and development and also can affect their quality of life [5].

Despite a mandate for children's oral health services in public insurance programs such as Medicaid, access to dental care for preschool age children from low-income families is severely restricted. Rates of dental care utilization in this age group have been low historically because of many factors. Parents of preschool aged children often do not place a priority on oral health, there is a shortage of pediatric dentists in the United States, most general dentists are not trained to provide dental care to young children and many are less than willing to treat children insured by Medicaid because of its low reimbursement rates compared to private insurance [6]. Early intervention strategies that go beyond the traditional dental clinic setting are increasingly being tested for their potential to reduce the burden of ECC among preschool children. Such interventions include linking dental screening and risk assessment activities with well-child care or immunization schedules, early establishment of a dental home, and the use of fluoride varnish [7-9].

One particular approach that is gaining popularity across the U.S. is to expand the sites where early preventive oral healthcare is provided to include the pediatric primary care settings where infants and toddlers are seen far more frequently compared to a dentist's office. Physicians already assess oral health during well-child visits and are encouraged by guidelines from the American Academy of Pediatrics to include oral health counseling in the anticipatory guidance they provide to parents [10]. Self-reported data suggest that family physicians and pediatricians are willing to play an active role in ensuring the dental well being of their child patients. In a recent national survey, Lewis et al. [11] found that pediatricians believe they can play a role in promoting the oral health of their child patients. Further, a majority of the pediatricians responded that they would be willing to include anticipatory guidance for oral health in their practices.

Apart from their long-term goal of preventing ECC through parent counseling and fluoride applications, most of these medical office-based programs also stress the importance of oral health risk assessment and referrals to dentists for children with ECC or those considered to be at elevated risk as a way of addressing children's more immediate dental needs. However, little evidence exists about how often physicians provide dental referrals and when they do, whether their referrals facilitate access to and use of dental care by children receiving the referrals. Two previous studies of a program in North Carolina named Into the Mouths of Babes (IMB), which started reimbursing medical providers in 2000 for providing preventive oral health services, have explored the question of referrals and referral outcomes. A total of 24,403 children with IMB visits during 2001 and 2002 from 140 medical practices in 71 NC counties were included in those studies. Results from those analyses suggest that the presence of physician-detected ECC in children and the availability of general dentists are important predictors of receiving a referral [12]. Further, children receiving a dental referral from a physician participating in IMB, particularly those with ECC, are more likely to have early use of dental care than those without ECC [13].

To further examine the role of referrals in facilitating children's access to dental care the current study focuses on an expanded number of medical practices participating in the NC IMB program using more recent information than the previous two studies. The two previous studies provided important information on the predictors of referrals and the effect of referrals on children's use of dental care. However, those studies were restricted to the initial demonstration phase of the IMB program and included only a subset of all children who received IMB services during 2000-2002. The current study is an intent-to-treat analysis of the effect of receiving well-child care in an IMB participating medical practice on time to a dental visit for children before 3 ½ years of age compared to the receipt of well-child care in a non-IMB practice. The premise for this analysis is that physicians' training in oral health risk assessment and screening as part of the IMB program will increase the likelihood that they will provide referrals for children identified as having ECC or being at high risk for the disease. Medical practices participating in the IMB program should have more motivation and better referral systems in place than practices not participating in that program. These provider and practice characteristics should be reflected in an increase in dental visits for children having well-child visits before three years of age in practices participating in IMB compared to those children who have well-child visits in practices not participating in IMB.

6.3. Methods

Overview of study design and analysis

This prospective cohort study uses data for children born on or after July 1, 2003 who were enrolled in the NC Medicaid program for at least some portion of the period from January 1, 2004 through December 31, 2006 and received well child services in pediatric and family medicine practices in North Carolina as recorded in Medicaid administrative files. The medical practices providing well-child services were classified into two groups based on whether they participated in North Carolina's preventive oral health program, Into the Mouths of Babes (IMB). Practices identified as IMB participants were further classified as high or low volume IMB practices according to a three-month moving average of the number of IMB visits that occurred in the practice as a proportion of the well child visits for Medicaid-enrolled children during 2004-2006. Children were linked to practices based on their first claim for a well-child visit (WCV) after turning 5 months of age. The time to the child's first dental visit from his or her first WCV was modeled using a piecewise exponential model.

The NC Medicaid program started reimbursing pediatric medical practitioners who provided preventive dental care for Medicaid-enrolled children from birth through 35 months as part of the IMB program in 2000. The IMB program is offered in medical offices by providers who complete training regarding fluoride application, detecting dental decay and identifying those at high risk. This training follows guidelines from the American Academy of Pediatrics that recommends the referral of children to the dentist before three years of age, but only for those children who already have ECC or are at high risk for disease [14]. IMB visits include oral health screening, risk assessment, and referrals when indicated, parent counseling about infant oral health, and the application of fluoride varnish to children's teeth. According to Medicaid policy in effect during the time when this study was conducted, children could receive up to six IMB visits, separated by at least 90 days, before the child's third birthday.

Conceptual framework for the analysis

We draw on a framework of physicians' role in preventing ECC among children proposed by the U.S. Preventive Services Task Force. This framework is based on a systematic review that assessed the effectiveness of various activities performed by primary care practitioners in preventing ECC among preschool age children [15]. According to this Task Force, primary care clinicians should provide dental screening, risk assessment and referrals for dental care as part of medical care for their young patients. The approach is based on triaging children according to risk, where only those with ECC, or those determined to be at high risk for ECC are referred to a dentist. This approach is more conservative and realistic than other recommendations that suggest all children should be referred to a dentist by one year of age [16] and is supported by the AAP guidelines [14].

Because the data for this study lack information on the child's ECC status, we are limited in assessing whether the documented dental visits are a result of referrals by physicians for pre-existing disease, because the child was identified as being high risk by their physician, or for any other reason. Rather, the measure of effectiveness in this context is whether participation in a program focused on preventive oral health affects the time to a dental visit for children in need of those services (assuming that those making visits are the ones with dental needs). We therefore expect that children seen in IMB practices will show evidence of making dental visits earlier than those from non-IMB practices at young ages because the IMB program might facilitate their access to a dentist for risk or pre-existing disease. If effective referral for elevated risk or disease occurs, we would expect the dental visit to occur in the short-term (e.g., within the first six months) after the well-child visit. In the longer-term, however, it might be difficult to separate the effects of referrals from the preventive effect of IMB, which might delay children's need to see a dentist until an older age. The ability to detect a referral effect using the intent-to-treat analysis will depend on the number of children referred, the effectiveness of the referral and the balance of the referral and preventive effects over the period of time children can be followed in the study.

Sample identification and selection

A multi-step process was used in this study to select the time period and sample of practices and patients from Medicaid administrative claims files. We excluded data from the initial demonstration period of the IMB program (years 2000 through 2003) because some practices experimented with providing IMB services, submitted few claims, and then decided not to continue with the program. By excluding data from the demonstration period we hoped to capture the effect of IMB during a more stable period of program implementation. The demonstration phase of the IMB program had ended by January 2004 and by including information from that time onwards we can account for children's experiences in a program that was reasonably well-established and widely adopted by many medical practices across the state. According to AAP and IMB recommendations, only children needing dental care should be referred, therefore we focused on the child's first IMB visit when disease, if present would likely be detected.

Because our interest is in identifying whether practice participation in IMB has an effect on children's ability to access dental care, the regressions models are estimated by aggregating data within medical practices according to each of three age groups. The two previous studies focused on individual child-level characteristics, such as disease levels and referral status, and their effects on dental use. The intent-to-treat analysis used for this study assumes that once a practice decides to participate in IMB, is trained to provide services and begins doing so, all children within that practice will be exposed to IMB services. This analysis is based on the initial intentions of the IMB program, not IMB services actually provided, thus providing important information about statewide impact of the program on access to dental care.

Steps in the selection of medical practices

The steps involved in selecting medical practices and patients within these practices are outlined in the following sections and are displayed graphically in Figure 6.1.

1. Identify practices that provided well-child visits during 2004-2006.

Because the majority of IMB services are provided as an adjunct to a WCV, we first identified medical practices in the Medicaid data that submitted at least one claim for a WCV for reimbursement to the NC Medicaid program during 2004-2006 (see Figure 6.1). Of these 1,298 practices, 914 were identified as providing WCVs without submitting any claims for IMB services.

2. Identify practices that provided well-child visits and IMB services during 2004-2006.

We first calculated three-month moving averages for IMB and well-child visits. Practice participation in IMB was defined using a ratio of the IMB three-month moving average to the WCV moving average for each medical practice. In calculating the moving average, we noted that a number of health departments had evidence of providing IMB services, but very low levels of WCVs. Because health departments tend to differ from other pediatric primary care settings in the services they provide, and many have dental clinics located on site, they may find it easier to refer patients for dental care. For these reasons, we excluded health departments from the current analysis. Thus, the sample for this study was restricted to pediatric and family medicine practices, and excluded health departments and any other private practice that had a three-month moving average of IMB to WCV between 0 and .05% (N=106).

3. Classify IMB practices as high or low volume participants.

The number of well-child visits and IMB services provided by practices that participate in the IMB program varies widely. For example, there are differences in the number of children served by certain pediatric practices that see a high volume of Medicaid-insured children compared to some family medicine practices that see only a handful of these children. In order to account for this difference in a practice's IMB participation and the volume of well-child services they provide, we decided to further classify IMB practices as either high or low volume participants in the program. Evidence from quarterly reports provided by the NC Division of Medical Assistance indicates that statewide IMB services currently are provided in about 30 percent of WCVs for 1- and 2-year-old children in practices participating in the

IMB program. To classify IMB practices as low and high volume IMB practices we therefore chose to use .30 for the threshold value of the ratio of three-month averages of IMB to WCVs. Hence, any practice that during 2004 provided IMB services in greater than an average of 30% of its WCVs for any three-month period was classified as a high volume IMB practice (N=63). Practices with IMB to WCV proportions between .05 and .30 were classified as low volume IMB practices (N=215).

Selection of children within medical practices

The analysis for this paper focuses on the effect of practice participation in IMB on children's use of dental care. Therefore it is advantageous to include children in the sample who can be followed for the longest amount of time in the Medicaid data. For this reason we selected children with birth dates on or after July 1, 2003 so children would be six months of age or older on January 1, 2004. The sample also was restricted to children who had at least one WCV during the three-year study period. The first criterion ensured that we were able to capture the full experience of children who received WCVs and IMB services during 2004-2006 (N=167,358). The second criterion allowed for a comparison of the time to a dental visit from the child's first WCV for children seen in IMB and non-IMB practices.

Data Sources

This study included data from the following sources:

1. *<u>Medicaid enrollment and claims files</u>*

NC Medicaid claims and enrollment data were obtained from the NC Division of Medical Assistance (DMA), the agency that administers the Medicaid program in the state.

Medicaid claims data for January 1, 2004 through December 31, 2006 were included in this study. The sample was restricted to children born on or after July 1, 2003 who were enrolled in the NC Medicaid program during 2004-2006. Claims data provided detailed information about claims submitted by physicians for reimbursement of well-child visits and IMB services, and claims for dental treatment submitted by dentists participating in the NC Medicaid program. The enrollment files provided information on the child's date of birth, race, sex, county of residence and dates of enrollment in Medicaid. A third file containing information about medical providers participating in the NC Medicaid program for the study period was used to identify the type of practice (pediatric, family medicine, health department) where a medical visit occurred. Henceforth, these three datasets (enrollment, claims and provider file) will be referred to as the "Medicaid data."

2. <u>County-level information</u>

The Area Resource File (ARF) was used to obtain the rural or urban status of all 100 counties in NC [17]. This variable was derived from information on the degree of urbanization of the county of residence of the child and is based on the rural-urban continuum codes of the US Department of Agriculture [18]. The continuum codes comprise a 7-category variable that captures the degree of urbanization of a county based on its proximity to a metro area with a population of 1 million or more. This classification categorizes each county according to the population size of its metro area and for rural counties, its degree of urbanization and proximity to a metro county. A rural county is considered to be adjacent to an urban county if it lies physically adjacent to the urban county and at least 2% of its labor force commutes to the central urban county. We collapsed these codes to allow comparison of urban to rural counties in our analyses. This information was merged with the Medicaid data using the child's county of residence at the time of his or her first WCV.

Construction of the analytic file and analysis strategy

We used discrete-time survival analysis to model the time to the first dental visit in a dental office subsequent to the child's first WCV visit in the medical office. Our hypothesis was that controlling for the child's age and urbanization status of his or her county of residence, having a WCV in a practice that participates in IMB is likely to facilitate use of dental care. Therefore, children who received well-child services in IMB practices should see a dentist earlier (within the first six months after a WCV) than those who do not receive the same attention from the physician. Thus, the failure event (a 0/1 variable) was identified by the presence of a claim submitted by a dentist for the child, following his or her first WCV. For children who did not have a dental visit, the censoring variable was defined as the number of months between the child's first WCV and the end of their Medicaid enrollment or the end of the data, i.e., December 31, 2006. We chose to use the presence of a dental claim rather than evidence of a treatment or preventive visit as the failure event because the focus of this study was on the effect of the IMB program on time to a dental visit, not on the appropriateness or type of care needed or received.

Because of the infrequent occurrence of dental visits among preschool age children, and because of our interest in estimating practice-level effects of being seen in an IMB practice on dental utilization, we used a piecewise exponential survival model for our analysis [19, 20]. This analytical approach is commonly used for the analysis of grouped survival data and can be easily implemented to compare survival rates for the various groups in a study to determine whether a treatment effect exists or not. In this study, the model provides estimates of survival rates for children aggregated into three age groups (<=12 months, 13-24 months and 25-36 months) from rural and urban counties seen in the three types of medical practices (practices providing WCV services only, WCV + High volume IMB practices and WCV + Low volume IMB practices).

The analytic file consists of counts of failure and censoring events for children at risk for a dental referral during discrete periods following the WCV stratified by the child's age, county of residence and practice-level. To construct this file we first used child-level Medicaid data to create child-month observations for every month that the child was enrolled in Medicaid during the three-year study period. The failure and censoring events were used to construct the time in months between the first WCV and the first dental claim, or between the first WCV and the end of Medicaid enrollment as described above.

We then used the variables for months between WCV and failure or censoring to determine within each of 5 time periods a child's time at risk and whether the child used dental care. The five time periods were chosen to coincide with the WCV schedule (0-3 months; 4-6 months; 7-12 months; 13-24 months; and 25-36 months). The reason for using these specific time intervals was that physicians should provide referrals for children at the visit they see evidence of ECC in a child and if these referrals facilitate dental care access, children should make a dental visit soon after the WCV at which the referral was provided. In this approach to splitting the time to dental visit into intervals children can contribute to multiple time intervals if they are followed for more than one time period without having either a dental visit or being censored. For example, a child who had a dental visit seven months after their first WCV would contribute three months each to the first and second time periods and one month to the third time period. It is important to note that certain time intervals for children age 25-36 months have no observations because all children in those intervals were censored (or had a dental visit) in the previous period. These 25-36-month time intervals without observations include the three practice types in both urban and rural counties.

For the multivariable analysis, the data from 167,358 children were aggregated into a four-way contingency table with categorical variables with levels for the three medical practice types, five time periods, three age groups and rural or urban county classification, as described in the previous section. This aggregation yielded 90 rows of data, corresponding to as many cells in the contingency table, which were entered into a piecewise exponential model for time to use of dental care. In the first step, we estimated a model that included main effects for the two types of IMB practices (high, or low volume IMB vs. WCV only), the time variable that is used to group the observations, child's age and residence county's urban versus rural status. These variables are interacted with type of medical practice and also included are interactions for the time and age variables.

In order to arrive at a parsimonious model, a series of likelihood ratio tests were used in a process of backward elimination to remove groups of interaction terms that were not statistically significant. Period-specific conditional probabilities of survival from the final model were then used to estimate unconditional (cumulative) survival rates for the various groups. Because the dependent variable in the analysis is a count of the number of dental visits, it is modeled in the piecewise exponential model using a poisson distribution. Overdispersion (where the variance of the count variable is greater than its mean) is a common problem in data with a poisson distribution. Therefore, the standard errors in the final model are adjusted via a scale parameter to account for this overdispersion. Further, to account for the clustering of child-observations from the same practice we identify and control for 30 clusters in the multivariable analysis. These clusters represent child observations from each of the five time periods, within the three practice types (WCV only, high volume IMB or low volume IMB) in rural (or urban) counties. The delta method for calculating the variance of a non-linear function was used to obtain model-based standard errors for estimates of the survival rates [21]. All analyses were conducted using SAS® version 9 (SAS, Cary, NC, USA) and Stata® version 9 (Stata Corp., College Station, TX, USA).

Study variables

Dependent variable

The dependent variable in this study was an aggregated count of the number of events (i.e., claims for dental visits) submitted by each of the three types of medical practices, for the three age groups, the five time periods and the urban or rural classification of the child's county. This variable is modeled as a poisson count in the piecewise exponential model. A log transformation for the number of exposure months contributed by children during each of the five time periods was used as an offset (denominator) in the analysis. For children with a dental visit, these exposure months were calculated based on the number of months from the child's first WCV to his or her first dental visit as evidenced by the presence of a claim for a dental visit for any reason that was reimbursed by the NC Medicaid program. For children without a dental visit during a period, the exposure months were calculated as the number of months from the child's first WCV to the end of the period of their observation or the end of the data (December 31, 2006).

Main explanatory variable

The main explanatory variable in this analysis was the type of medical practice where the child's first WCV occurred. This variable classified medical practices into three types based on whether or not it participated in the IMB program and if so, its level of participation. As previously described, the classification was: 1. practices providing only well-child visits, but no IMB visits; 2. practices providing well-child visits and classified as low volume IMB participants (>.05 - ≤.30 IMB visits: WCV); and 3. practices providing well-child visits and classified as high volume IMB participants (>.30 IMB visits: WCV).

Child-level control variables

Statistical inference based on maximum likelihood estimation of the piecewise exponential model requires sufficiently large failure counts across the cells of the contingency table, placing limits on the number of variables that can be controlled for in the analysis. We therefore identified the most important variables that were likely to affect both ECC rates and rates of dental visits in our study population, and controlled for those in the multivariable analysis. Because of the high correlation between age and the likelihood of visiting a dental visit, we controlled for the child's age at their first well-child visit using three dichotomous indicators (<=12 months (infants); between 13-24 months (toddlers); and, 25-36 months (children)). Because of variations in the availability of dental providers and water fluoridation between rural and urban areas, we controlled for the urbanization status of the child’s county of residence using a dichotomous indicator of whether or not the child resided in a rural county at the time of his or her first WCV.

6.4. Results

Child and provider characteristics of the study sample

The study sample included data for 167,358 children born on or after July 1, 2003 who had their first well-child visit during 2004-06 in one of 1,192 medical practices in North Carolina. Table 6.1 provides descriptive statistics for the study sample. The average age of children in the sample was 7.4 months, and white, black and Hispanic or other race children represented approximately 42%, 33% and 22% of the sample, respectively. The majority of the sample was comprised of children who were living in an urban county at the time of their first WCV. More WCV visits occurred in practices classified as low IMB participants, compared to practices classified as WCV only or high volume IMB practices, and medical practices in the study sample averaged about .18 IMB visits per WCVs in a month. Overall, there were 16,634 (9.9%) dental visits recorded for the 167,358 children in the study. In documenting dental visits by the three age groups, children less than 12 months in age had the most dental visits following their first WCV (N=14,601), followed by children aged 13-24 months (N=1,247) and those aged 25 months or older (N=786) at their first WCV.

Table 6.1 also includes the characteristics of the 20,805 children who had a WCV in one of the 106 health departments or medical practices that were excluded from the sample (see Figure 6.1) because of an IMB to WCV ratio that was greater than 0, but less than .05. The average age, and months between the first WCV and dental visit for the included and excluded groups is similar. However, the excluded group had fewer children living in a rural area than the study sample (23.1% vs. 35.8%).

Results of the multivariable analysis

Table 6.2 presents the model with main effects for practice type (high and low volume IMB vs. WCV only), the five time periods (4-6, 7-12, 13-24 and 25-36 vs. 0-3 months), child's age at first WCV (ages 13-24 and 25-36 vs. <=12 months) urbanization status of child's residence county at the time of the WCV (rural vs. urban), and all pairwise interactions. Specifically, the time dummies are interacted with practice type, the rural county indicator, and child age. Interactions also are included for rural and practice type, child age and practice type, and rural and child age. The results of the LR test used in the process of backward elimination of interaction terms indicated that the interaction of practice type and child's age was not statistically significant and could be dropped from the all pairwise interactions model (see Table 6.3). The resulting model was then re-estimated with the scale parameter to account for over-dispersion in the model. In this model the two interaction terms between practice type and rural status of the child's residence county and one of the interaction terms between practice type and time of the WCV became insignificant. The ten interaction terms (2 for practice type and rural status and 8 for practice type and time of WCV) were therefore excluded from the final model presented in Table 6.4. Controlling for the age of the child at first WCV, rural or urban status of child's county of residence and the number of months between the first WCV and the dental visit, children seen in high volume IMB practices exhibit longer time to a dental visit compared to children seen in WCV only practices.

The survival rates estimated from the final regression model displayed in Table 6.4 are presented in Table 6.5 along with a distribution of the number of children who had a dental visit or were censored during each of the five time periods, and the number who made it satisfactorily through each time period (labeled 'Satisfactory'). Results are stratified by practice type, urban or rural child county of residence and the child's age. The variable labeled months indicates the child-months of exposure for each time period and the last four columns in the table provide estimates for the survival rates for each group and model-based standard errors and confidence intervals for the survival rates.

The survival rates for the WCV only and high volume IMB groups stratified by the population density classifications of the child's residence county are plotted for ease of interpretation in Figures 6.2 and 6.3. We omit the low IMB group from the graphs because the coefficient for this variable is not significantly different from the WCV only group. Overall, the survival rates follow the same pattern across urban and rural counties wherein, across all three age groups, the high volume IMB group has fewer children with a dental visit than the WCV only group.

6.5. Discussion

The pediatric primary care setting is growing in popularity as a site for preventive oral health interventions. Currently as many as 13 states reimburse primary care practitioners for providing preventive oral health services including oral health risk assessment, screenings and referrals, fluoride varnish applications and parent counseling about infant oral health. This recent innovation in preventive oral health holds promise for expanding the sites for delivering preventive oral health care. Research suggests that these services can be easily incorporated into busy primary care practices [22], providers are enthusiastic supporters of such programs, and parents report a high level of satisfaction with the services received from their child's pediatric primary care provider [23]. This innovation in pediatric primary care has spurred many questions about the effectiveness and appropriateness of such services and their impact on children's access to dental care.

This study is the first to examine the effects of medical practice-level adoption of a preventive oral health program being promoted by a state Medicaid program (IMB) on children's time to a dental visit. The main hypothesis of this study was that participation in the IMB program would lead to an increased emphasis on oral health, which in turn would result in an initial increase in dental visit rates for children receiving well-child services in participating medical practices compared to practices not participating in IMB. We also expected to find IMB practices with the largest ratio of preventive dental services to well-child visits to have higher rates of visits to the dentist than IMB practices having a smaller ratio. We found, however, that these hypotheses were not supported by the results of this study. In contrast, we found that for all age groups dental visit rates are lower for high volume IMB practices than WCV only practices. Rates for the low IMB practices fall between the other two groups, but are statistically similar to the WCV only practices.

Although these findings are contrary to our expectations, they are not surprising for several reasons. The incidence of ECC is low in the ≤12 month age group of children and physician referral rates for this condition are low, partly because they under-refer children in need of dental treatment. In a previous study of child-level predictors of dental referrals among a sample of children (N=24,403) who received IMB services during the demonstration phase of the program (2000-2002), we found that less than 3% of children were referred by physicians for dental care, and even among children with at least one decayed tooth, only about 33% were referred to a dentist [24]. Similarly, a study by dela Cruz and colleagues suggests that physicians have a tendency to under-refer [22]. With such low rates of referral, evidence of under-referrals and overall low rates of dental care utilization for Medicaid-insured populations in general, it is not surprising that we did not find an increase in dental use (an approximate measure of referrals) in a much larger sample of children where treatment group assignment was determined by a WCV and whether the practice was an IMB participating practice or not.

Another important reason that we did not find a referral effect in this analysis could be because the IMB intervention includes several interventions with the potential for competing and different outcomes. Counseling and fluoride varnish should reduce the incidence of disease and thus reduce the need for and demand for dental use. On the other hand, screening and referral should increase demand for dental use for the small number in need. The practice-level, intention-to-treat analysis conducted for this study should be able to detect the effect of the intervention having the predominate effect. The survival rates will capture the predominant effect, which appears to be the preventive effect.

Our previous study [24] used data from the demonstration phase of the IMB program when there was little opportunity for the preventive effect of IMB to dilute the referral effect of the program. Because many of the children receiving IMB services during the demonstration phase did not receive IMB preventive services at an early age (the time of initial tooth eruption), the IMB program could not prevent the dental disease that developed in these children. Unlike the previous study, the current study followed children born on or after July 1, 2003 and thus had the ability to capture the full effect of the program for these children because the oldest child in this cohort would be six months of age on January 1, 2004. It is likely that for these children early exposure to the preventive aspects of IMB including, fluoride treatments and parent oral health counseling was able to offset tooth decay and the need for referrals.

Lastly, physicians from many practices that started participating in the IMB program during its initial implementation received training in oral health risk assessment and screening at the time of their enrollment in the program. Three years or more could have elapsed between training and assessments used in this study. Efforts to provide ongoing continuing education and quality improvement activities for these practices have not been implemented on a uniform basis. Many provider and staff changes also can occur over time, thus attenuating the effectiveness of the original training. Thus, practices that diligently provided referrals early in the adoption of the program may have had a tendency to reduce their referral activity as time went by, precluding us from finding a referral effect for those practices in the later data.

About ten percent of children in our sample made a dental visit, and children in the youngest age group of less than or equal to 12 months of age at their first WCV had the most dental visits following their WCV. These results are consistent with the design of the study where children were followed for a maximum of three years, so those who had their first WCV at an earlier age had more opportunity for their dental visits (before three and a half years of age) to be captured in the data used for this study. More dental visits were documented for children who resided in an urban county at the time of their first WCV. This finding is consistent with higher dental utilization among urban counties as opposed to rural counties and likely reflects the greater availability of dental providers in urban areas.

Evidence from at least one study indicates that the county can be considered a marker for a dental service market area [25]. However, we were unable to account for other factors, not at the county level, that might contribute to differences in dental utilization rates between urban and rural counties such as travel time to the dentist and availability of public transportation.

Overall, the time to a dental visit following a WCV was significantly longer for the high volume IMB group as compared to WCV only practices. This finding suggests that exposure to the IMB program may have a beneficial effect for children in terms of reducing the need for a dental visit. However, future research needs to examine these differences after accounting for child age and possibly disease status. It is important to note that we followed children forward from the time of their first WCV, but many children may have had additional office visits when they would have had the opportunity to be exposed to the IMB program. We did not account for this possibility of additional WCVs or sick visits in our analysis. Nevertheless, WCVs are by far the more common type of medical visit that children of preschool age are likely to make and therefore excluding sick visits is unlikely to have biased our results to a great extent.

Limitations

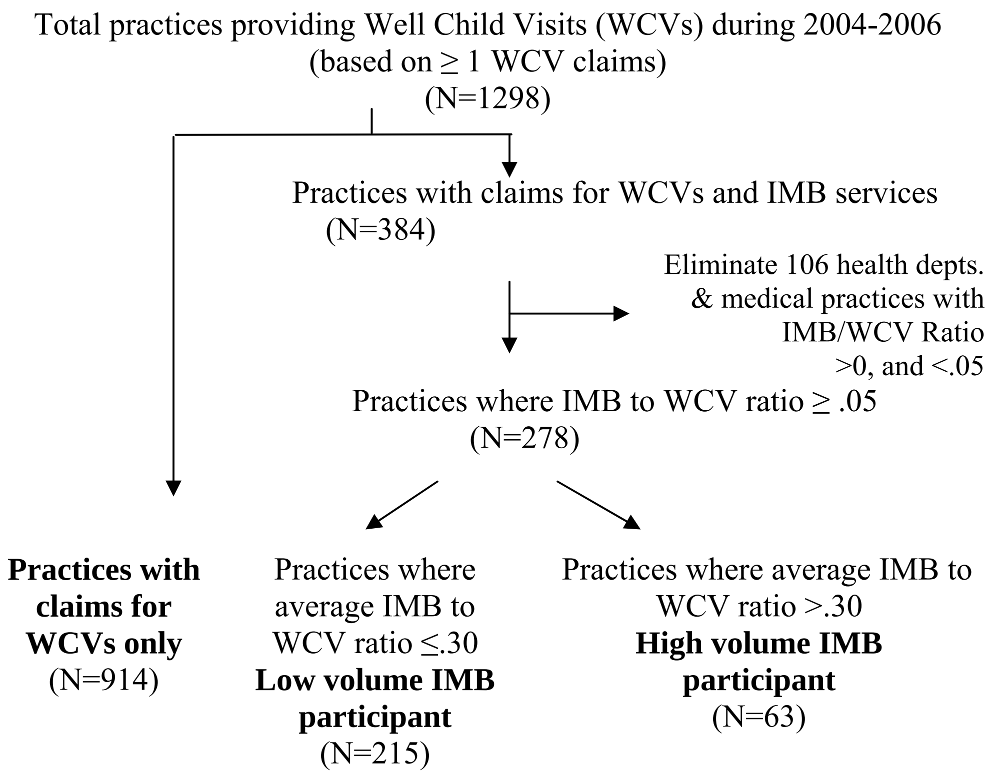
An important limitation of the presented analyses is that no information was available on the child's ECC status. However, child's age usually is highly correlated with the number of teeth and the presence of tooth decay and therefore likely controls for some of the effects of having ECC. We used a sequential process for arriving at the study sample, which may have potentially biased the sample. However, several reasons make it unlikely that the derived sample is biased and does not represent the NC Medicaid-enrolled population. The study was restricted to a high risk group of children receiving well-child care in medical offices from the entire state of North Carolina. Because it is unlikely that children travel a great distance to receive their preventive care, there is no reason to believe that Medicaid-enrolled children seen in IMB and non-IMB practices would have different characteristics.

The definition of high and low volume IMB practices could result in misclassification of practices. Although the definition accounts for the volume of WCV occurring in a practice, we used a static three-month average for the cut off to define high and low volume IMB practices. We used this approach to simplify the analysis and to avoid using a time varying variable in our regression models. However preliminary analyses of the effect of this decision suggest that there might be value in exploring other cut offs rather than the 30% value that we used to explore the relationship between IMB participation and time to a dental visit.

Conclusions

Although we did not find a referral effect, our analyses indicate that practice participation in IMB has a protective effect on children receiving well child visits in those practices, and delays dental visits compared to practices that provide WCV, but do not participate in the IMB program. Results indicate that the preventive effect of IMB exists for all ages, but needs further examination to separate the effects of referrals and prevention, which likely differ by the child's age. Future research also needs to consider the presence of ECC as an important outcome variable in examining the preventive effect of medical office-based preventive oral health programs. Although we were unable to document a referral effect for IMB, previous evidence suggests that it exists. In this study the referral effect appears to have been offset by the stronger preventive effect of the IMB program. Future research therefore needs to include a larger sample of children to examine both the preventive and referral effects for the same group of children.

Figure 6.1. Selection of medical practices



Practice type	WCV only	WCV + Low volume IMB	WCV + High volume IMB	Total
	914 (76.7% of Total)	215 (18% of Total)	63 (5.3% of Total)	1192

Table 6.1. Descriptive statistics for the study sample

Child characteristics	Study group (N=167,358 children) Mean or Percent	Standard deviation	Excluded group (N=20,805 children) Mean or Percent	Standard deviation	Range
Child's age in months at well-child visit	7.38	4.50	8.45	5.91	6–36
Child is male (vs. Female) (%)	57.78	.50	51.62	.50	0-1
Child's race (%)					0–1
American Indian	1.75	.13	.31	.06	
Asian	1.25	.11	1.30	.11	
Black	32.73	.47	30.49	.46	
Other, Unknown or Hispanic	21.88	.41	15.90	.37	
White	42.39	.49	51.99	.49	
Child lives in a rural (vs. urban) county (%)	35.81	.48	23.09	.42	0-1
Child had a dental visit following his or her first well-child visit (%)	9.94	.05	11.49	.08	0-1
Months between first WCV and first dental visit	15.45	8.73	13.05	8.50	0-35
Months between first WCV and end of monthly observations for children with no dental visit	14.31	9.54	12.88	9.04	1-36
Provider–level variables					
Type of setting for IMB services (%)					0–1
Well-child visit only practice	29.36	.46	-	-	
Low IMB practice	46.89	.50	-	-	
High IMB practice	23.75	.43	-	-	
Three-month moving average of # IMB visits per three-month moving average of # well child visits	.18 (0.0-1.0)	.15	.02 (>0.0-.05)	.04	

Table 6.2. All pairwise interactions model for time to use of dental care from first well-child visit

Parameter	Estimate	Std. Error	ChiSq	*P*-value
Intercept	–6.488	.066	9825.01	<.0001
Type of practice (vs. Well-child visit only practice)				
High intensity IMB practice	–.437	.097	2.69	<.0001
Low intensity IMB practice	–.043	.073	.35	.5526
Time (in months) from first WCV to dental visit (vs. 03- months)				
4-6 months	.809	.079	105.25	<.0001
7-12 months	1.661	.071	56.89	<.0001
13-24 months	2.118	.069	954.21	<.0001
25-36 months	2.71	.074	1328.58	<.0001
Child was living in a rural county at time of first WCV (vs. Urban county)	–.313	.078	16.4	<.0001
Child's age (in months) at time of first WCV (vs. <=12 months)				
13-24 months of age	2.579	.079	1072.13	<.0001
25-36 months of age	3.565	.085	1759.54	<.0001
Interaction of practice type (vs. Well-child visit only practice) and time (in months) from first WCV to dental visit (vs. 03- months)				
High intensity IMB practice * Time 4-6 months	–.01	.12	0	.9573
High intensity IMB practice * Time 7-12 months	–.025	.103	.06	.8102
High intensity IMB practice * Time 13-24 months	.241	.099	5.84	.0157
High intensity IMB practice * Time 25-36 months	.331	.108	9.48	.0021
Low intensity IMB practice * Time 4-6 months	–.005	.088	0	.9551
Low intensity IMB practice * Time 7-12 months	.010	.079	.02	.8928
Low intensity IMB practice * Time 13-24 months	.119	.076	2.5	.1139
Low intensity IMB practice * Time 25-36 months	.015	.084	.03	.8618
Interaction of time (in months) from first WCV to dental visit (vs. 03- months) and rural county of residence (vs. urban county)				
Time 4-6 months * Child from rural county	.052	.088	.35	.5568
Time 7-12 months * Child from rural county	–.215	.079	7.29	.0069
Time 13-24 months * Child from rural county	.039	.077	.27	.6033
Time 25-36 months * Child from rural county	.158	.083	3.64	.0564

Table 6.2. All pairwise interactions model for time to use of dental care from first well-child visit, contd.

Parameter	Estimate	Std. Error	ChiSq	*P*-value
Interaction of time (in months) from first WCV to dental visit (vs. 03- months) and child's age (in months) at time of first WCV (vs. <=12 months)				
Time 4-6 months * 13-24 months of age	–1.187	.099	145.13	<.0001
Time 7-12 months * 13-24 months of age	–1.918	.088	471.97	<.0001
Time 13-24 months * 13-24 months of age	–2.196	.089	604.22	<.0001
Time 25-36 months * 13-24 months of age	–2.98	.34	76.75	<.0001
Time 4-6 months * 25-36 months of age	–1.56	.11	208.4	<.0001
Time 7-12 months * 25-36 months of age	–2.49	.12	456.04	<.0001
Time 13-24 months * 25-36 months of age	–2.82	.22	174.44	<.0001
Interaction of rural county of residence (vs. urban county) and child's age (in months) at time of first WCV (vs. <=12 months)				
Rural * 13-24 months of age	–.063	.075	.72	.3967
Rural * 25-36 months of age	.279	.095	8.56	.0034
Interaction of type of practice (vs. Well-child visit only practice) * Rural county of residence (vs. urban county)				
High intensity IMB practice * Rural	–.115	.049	5.4	.0201
Low intensity IMB practice * Rural	–.078	.039	3.96	.0465
Interaction of type of practice (vs. Well-child visit only practice) * and child's age (in months) at time of first WCV (vs. <=12 months)				
High intensity IMB practice * 13-24 months of age	.116	.092	1.57	.2103
High intensity IMB practice * 25-36 months of age	.22	.12	3.16	.0756
Low intensity IMB practice * 13-24 months of age	.024	.070	.12	.731
Low intensity IMB practice *25-36 months of age	–.086	.094	.84	.3588
Scale	1	0		

Table 6.3. Results of the likelihood ratio tests for selected models nested within the all pairwise interactions model

Model	Excluded variables (compared to model A)	Degrees of freedom (df)	Log Likelihood	LR test statistic	*P*-value
A	p, a, t, r, p x a, p x t, p x r, t x r, t x a, r x a,		88357.0302		
B	p x a	4	88353.6554	6.7496	.1497
C	p x a, p x r	2	88350.4084	6.494	.0388
D	p x a, p x r, p x t	8	46269.2659	84162.29	.0001

Note: The LR test statistic is calculated as 2*(Log likelihood unrestricted – Log likelihood restricted model). The variables are defined as follows: p = practice type, a=age, t = time, r = rural. The final model excludes p x t and p x r based on non-significance of the interaction terms when the scale parameter is used to adjust the standard errors in that model.

Table 6.4. Final model for time to use of dental care from the first well-child visit

Parameter	Estimate	Std. Error	ChiSq	*P*-value
Intercept	–6.521	.067	9403.27	<.0001
Type of practice (vs. Well-child visit only practice)				
High intensity IMB practice	–.294	.042	91.18	<.0001
Low intensity IMB practice	–.013	.025	.3	.5834
Time (in months) from first WCV to dental visit (vs. 03- months)				
4-6 months	.798	.072	99.39	<.0001
7-12 months	1.654	.068	552.74	<.0001
13-24 months	2.215	.061	1053.39	<.0001
25-36 months	2.776	.072	1463.3	<.0001
Child was living in a rural county at time of first WCV (vs. Urban county)	–.371	.075	13.63	.0002
Child's age (in months) at time of first WCV (vs. <=12 months)				
13-24 months of age	2.605	.099	772.88	<.0001
25-36 months of age	3.556	.068	1489.17	<.0001
Interaction of time (in months) from first WCV to dental visit (vs. 03- months) and rural county of residence (vs. urban county)				
Time 4-6 months * Child from rural county	.05	.12	.16	.6903
Time 7-12 months * Child from rural county	–.22	.11	4.01	.0454
Time 13-24 months * Child from rural county	.04	.11	.12	.7284
Time 25-36 months * Child from rural county	.15	.11	1.8	.1795
Interaction of time (in months) from first WCV to dental visit (vs. 03- months) and child's age (in months) at time of first WCV (vs. <=12 months)				
Time 4-6 months * 13-24 months of age	–1.18	.14	75.45	<.0001
Time 7-12 months * 13-24 months of age	–1.91	.12	247.01	<.0001
Time 13-24 months * 13-24 months of age	–2.19	.12	319.68	<.0001
Time 25-36 months * 13-24 months of age	–2.99	.47	4.35	<.0001
Time 4-6 months * 25-36 months of age	–1.54	.15	107.55	<.0001
Time 7-12 months * 25-36 months of age	–2.47	.16	237.5	<.0001
Time 13-24 months * 25-36 months of age	–2.81	.29	9.65	<.0001

Table 6.4. Final model for time to use of dental care from the first well-child visit, contd.

Parameter	Estimate	Std. Error	ChiSq	*P*-value
Interaction of rural county of residence (vs. urban county) and child's age (in months) at time of first WCV (vs. <=12 months)				
Rural * 13-24 months of age	–.059	.103	.33	.5655
Rural * 25-36 months of age	.26	.13	3.96	.0465
Scale parameter (factor by which standard errors adjusted for overdispersion)	1.3817	0		

Table 6.5. Model estimated survival rates for time to dental visit from the child's first well-child visit

Rural County, Age <=12 months	FAIL	CENSOR	SATISFACTORY	KIDS	MONTHS	Survival rate	Std. Error	Lower 95% CI	Upper 95%CI
WCV only practice									
0-3 months	58	1337	13639	15034	43852	.996960	.000306	.996361	.997559
4-6 months	90	1844	11705	13639	39266	.989902	.012420	.965558	1.014245
7-12 months	257	4165	7283	11705	55950	.964897	.012178	.941029	.988765
13-24 months	576	4078	2629	7283	61038	.859337	.021414	.817365	.901309
25-36 months	319	2310	0	2629	15592	.684092	.058669	.569101	.799084
WCV+Low IMB practice									
0-3 months	92	2361	24610	27063	79033	.997000	.000310	.996393	.997607
4-6 months	181	3092	21337	24610	70953	.990031	.012803	.964938	1.015124
7-12 months	410	7836	13091	21337	101219	.965359	.012445	.940967	.989751
13-24 months	1059	7511	4521	13091	108370	.861072	.022007	.817939	.904205
25-36 months	455	4066	0	4521	26438	.687557	.059190	.571546	.803568
WCV+High IMB practice									
0-3 months	21	1185	12752	13958	40890	.997730	.000238	.997264	.998196
4-6 months	39	1628	11085	12752	36734	.992462	.010264	.972344	1.012580
7-12 months	159	3885	7041	11085	53923	.973724	.009880	.954360	.993089
13-24 months	420	4016	2605	7041	59534	.893178	.018302	.857307	.929049
25-36 months	242	2363	0	2605	15663	.753583	.054729	.646315	.860851

Table 6.5. Model estimated survival rates for time to dental visit from the child's first well-child visit, contd.

Rural County, Age 13-24 months	FAIL	CENSOR	SATISFACTORY	KIDS	MONTHS	Survival rate	Std. Error	Lower 95% CI	Upper 95%CI
WCV only practice									
0-3 months	28	111	655	794	2234	.961890	.005436	.951236	.972544
4-6 months	14	126	515	655	1821	.935438	.014973	.906091	.964785
7-12 months	30	226	259	515	2420	.891323	.016667	.858656	.923990
13-24 months	25	208	26	259	1587	.756537	.025174	.707196	.805878
25-36 months	2	24	0	26	72	.653262	.016624	.620680	.685844
WCV+Low IMB practice									
0-3 months	37	162	1046	1245	3531	.962390	.005451	.951706	.973074
4-6 months	28	188	830	1046	2928	.936271	.015487	.905917	.966624
7-12 months	27	387	416	830	3885	.892687	.017157	.859060	.926314
13-24 months	33	331	52	416	2767	.759356	.026071	.708256	.810455
25-36 months	1	51	0	52	135	.656979	.016434	.624770	.689189
WCV+High IMB practice									
0-3 months	18	73	491	582	1667	.971460	.004200	.963229	.979691
4-6 months	13	91	387	491	1360	.951477	.012610	.926762	.976192
7-12 months	13	169	205	387	1858	.917833	.013998	.890397	.945269
13-24 months	10	172	23	205	1288	.812273	.022638	.767902	.856643
25-36 months	1	22	0	23	59	.728121	.012532	.703559	.752684

Table 6.5. Model estimated survival rates for time to dental visit from the child's first well-child visit, contd.

Rural County, Age 25-36 months	FAIL	CENSOR	SATISFACTORY	KIDS	MONTHS	Survival rate	Std. Error	Lower 95% CI	Upper 95%CI
WCV only practice									
0-3 months	43	100	208	351	886	.870720	.027901	.816033	.925407
4-6 months	15	78	115	208	519	.812660	.030876	.752144	.873176
7-12 months	10	78	27	115	438	.736758	.028169	.681548	.791968
13-24 months	4	23	0	27	88	.536360	.021927	.493383	.579337
25-36 months	0								
WCV+Low IMB practice									
0-3 months	57	182	371	610	1559	.872330	.028196	.817066	.927594
4-6 months	25	142	204	371	923	.814913	.031561	.753055	.876772
7-12 months	11	142	51	204	777	.739770	.028776	.683370	.796171
13-24 months	2	49	0	51	152	.540839	.021718	.498272	.583405
25-36 months	0								
WCV+High IMB practice									
0-3 months	28	28	73	190	291	.901990	.023271	.856379	.947601
4-6 months	13	13	67	110	190	.856782	.027280	.803314	.910250
7-12 months	5	5	78	27	110	.796413	.024516	.748363	.844464
13-24 months	1	1	26	0	27	.628641	.016753	.595806	.661476
25-36 months	0								

Table 6.5. Model estimated survival rates for time to dental visit from the child's first well-child visit, contd.

Urban County, Age <=12 months	FAIL	CENSOR	SATISFACTORY	KIDS	MONTHS	Survival rate	Std. Error	Lower 95% CI	Upper 95%CI
WCV only practice									
0-3 months	129	2824	26330	29283	85283	.995590	.026899	.942869	1.048311
4-6 months	275	3609	22446	26330	75585	.985863	.030338	.926401	1.045326
7-12 months	838	8488	13120	22446	104528	.941371	.001587	.938260	.944482
13-24 months	1366	7306	4448	13120	107295	.800655	.021522	.758472	.842838
25-36 months	573	3875	0	4448	25701	.602829	.026738	.550423	.655235
WCV+Low IMB practice									
0-3 months	170	4641	40890	45701	132886	.997000	.027770	.942570	1.051430
4-6 months	360	5612	34918	40890	117333	.990031	.031125	.929025	1.051037
7-12 months	1301	12758	20859	34918	164009	.965359	.001659	.962108	.968610
13-24 months	2289	11743	6827	20859	168609	.861072	.021406	.819115	.903028
25-36 months	879	5948	0	6827	39002	.687557	.027716	.633234	.741881
WCV+High IMB practice									
0-3 months	73	2006	21128	23207	67711	.996710	.023047	.951539	1.041881
4-6 months	153	2709	18266	21128	60920	.989444	.027204	.936123	1.042765
7-12 months	416	6824	11026	18266	86353	.955971	.001298	.953427	.958515
13-24 months	948	6309	3769	11026	91080	.847325	.016712	.814570	.880080
25-36 months	453	3316	0	3769	21819	.685816	.041118	.605224	.766408

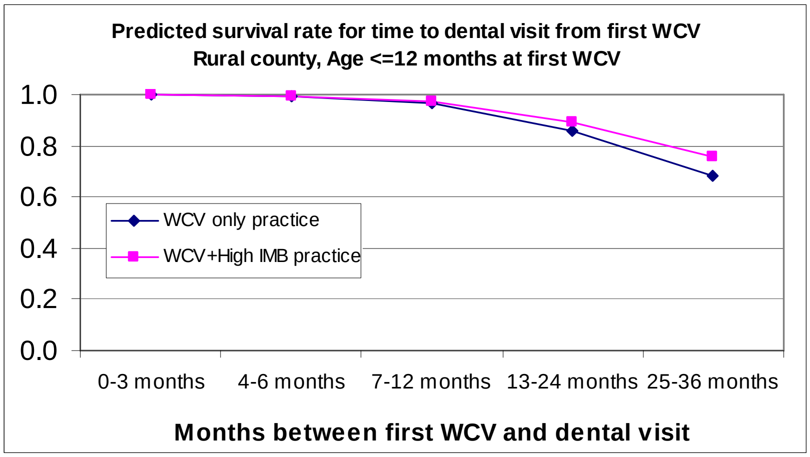
Table 6.5. Model estimated survival rates for time to dental visit from the child's first well-child visit, contd.

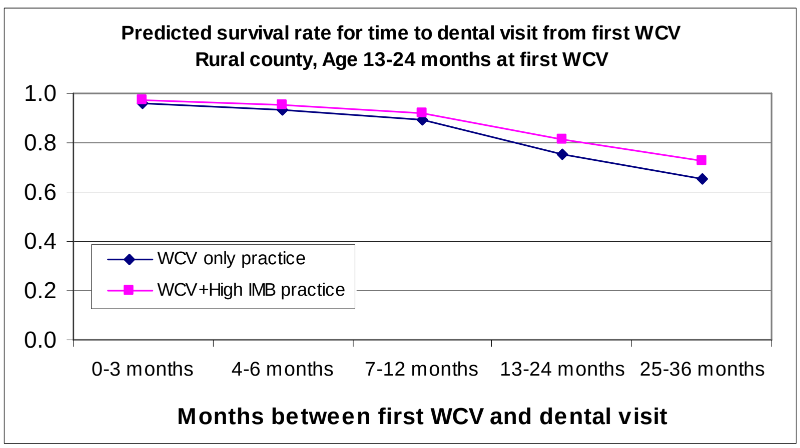
Urban County, Age 13-24 months	FAIL	CENSOR	SATISFACTORY	KIDS	MONTHS	Survival rate	Std. Error	Lower 95% CI	Upper 95%CI
WCV only practice									
0-3 months	136	334	1956	2426	6745	.941990	.028539	.886054	.997926
4-6 months	71	375	1510	1956	5419	.904263	.004623	.895202	.913325
7-12 months	108	668	734	1510	7104	.824335	.005602	.813356	.835315
13-24 months	82	576	76	734	4537	.646444	.023090	.601188	.691700
25-36 months	3	73	0	76	186	.532566	.023031	.487425	.577707
WCV+Low IMB practice									
0-3 months	151	521	1899	2571	6929	.962390	.029973	.903644	1.021136
4-6 months	79	365	1455	1899	5209	.936271	.004681	.927096	.945445
7-12 months	94	642	719	1455	6853	.892687	.005778	.881363	.904011
13-24 months	93	568	58	719	4381	.759356	.023331	.713627	.805085
25-36 months	1	57	0	58	133	.656979	.023955	.610028	.703931
WCV+High IMB practice									
0-3 months	40	155	980	1175	3323	.956450	.026542	.904428	1.008472
4-6 months	20	182	778	980	2751	.927757	.003612	.920678	.934835
7-12 months	45	356	377	778	3624	.865940	.004529	.857064	.874816
13-24 months	43	304	30	377	2281	.722471	.018887	.685452	.759490
25-36 months	1	29	0	30	69	.625335	.037254	.552317	.698353

Table 6.5. Model estimated survival rates for time to dental visit from the child's first well-child visit, contd.

Urban County, Age 25-36 months	FAIL	CENSOR	SATISFACTORY	KIDS	MONTHS	Survival rate	Std. Error	Lower 95% CI	Upper 95%CI
WCV only practice									
0-3 months	165	348	739	1252	3126	.856730	.012206	.832807	.880653
4-6 months	49	301	389	739	1819	.796048	.011407	.773690	.818405
7-12 months	30	292	67	389	1364	.694536	.019608	.656104	.732968
13-24 months	5	62	0	67	181	.493433	.070410	.355429	.631437
25-36 months	0								
WCV+Low IMB practice									
0-3 months	157	416	705	1278	3086	.872330	.012565	.847703	.896957
4-6 months	29	258	418	705	1777	.814913	.011590	.792196	.837630
7-12 months	39	272	107	418	1646	.739770	.019872	.700822	.778718
13-24 months	8	99	0	107	295	.540839	.070480	.402698	.678979
25-36 months	0								
WCV+High IMB practice									
0-3 months	62	62	139	332	533	.891170	.010049	.871474	.910866
4-6 months	13	13	121	198	332	.843697	.009118	.825826	.861568
7-12 months	11	11	140	47	198	.762146	.015965	.730855	.793437
13-24 months	4	4	43	0	47	.590754	.061516	.470183	.711326
25-36 months	0								

Figure 6.2. Predicted survival curves for time to a dental visit from the child's first well-child visit, rural counties





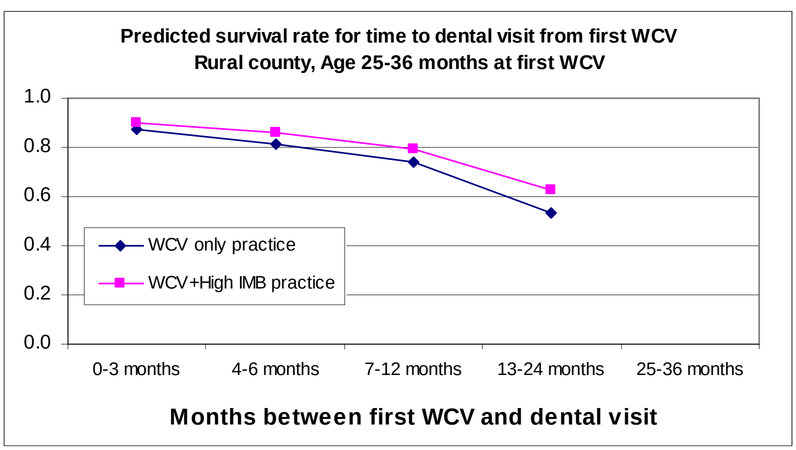
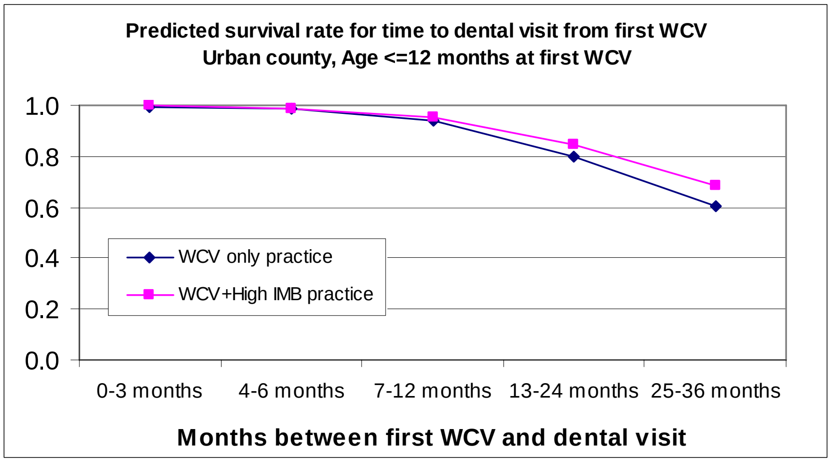
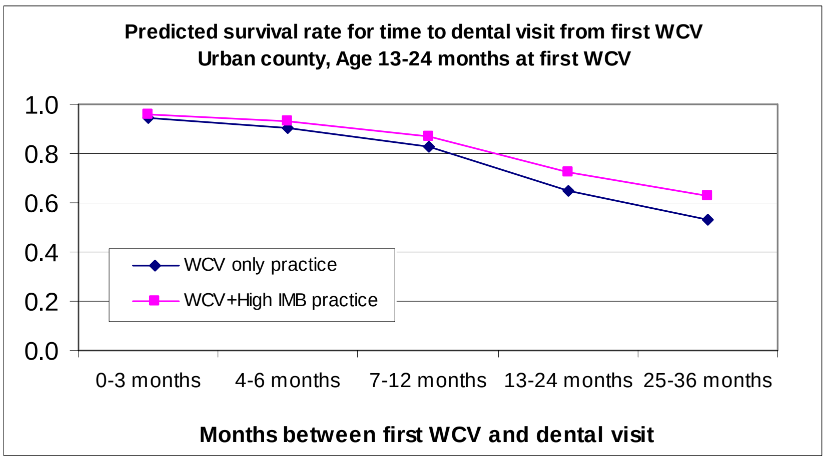
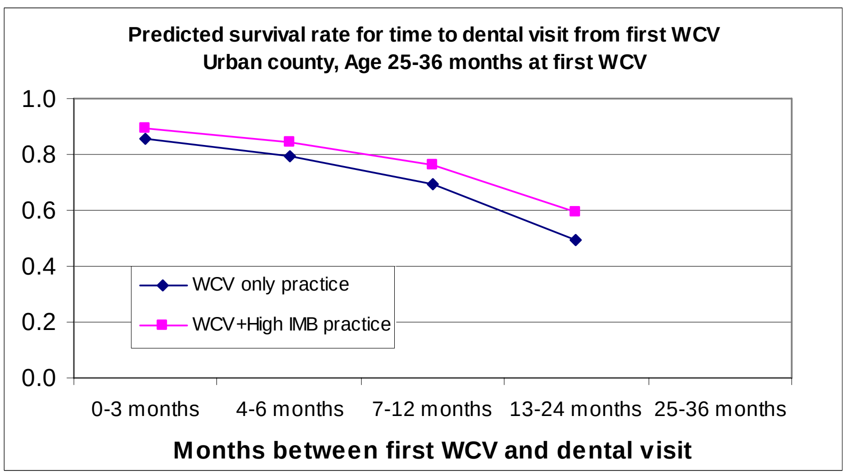


Figure 6.3. Predicted survival curves for time to first dental visit from the child's first well-child visit, urban counties







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7. DISCUSSION

7.1 Overview

Despite the requirement of Early, Periodic, Screening, Diagnostic and Treatment (EPSDT) services for children covered by the Medicaid program, few children receive early preventive dental services including, oral health risk assessments, dental screenings and referrals to dentists for problems detected during the screening [1]. These low rates of screenings and referrals usually are accompanied by poor rates of dental care utilization among low-income children and contribute to their growing burden of Early Childhood Caries (ECC) [2]. In response to these issues, many state Medicaid programs are engaging pediatric primary care providers in structured programs of delivering preventive oral health services for preschool age children during well-child (or other office) visits.

North Carolina has taken the lead in incorporating preventive oral health services into primary care medical practices through the implementation of an innovative medical office-based program known as Into the Mouths of Babes (IMB). Following numerous pilot studies, the NC Medicaid program began reimbursing providers in 2000 for providing: 1. oral health screening, risk assessment and referrals to dentists (as needed); 2. parent counseling about infant oral health; and 3. topical fluoride therapy for the child's teeth. The demonstration period for IMB ended in 2004, by when over 400 medical practices across the state were participating in the program [3].

Comprehensive medical office-based preventive dental programs are recent innovations in pediatric primary care; hence little evidence regarding the effectiveness of the various aspects of these programs has accumulated in the literature. Initial activities in North Carolina concentrated first on the development of the oral health intervention, then on training physicians to provide these services, followed by evaluation studies of provider adoption and impact on child oral health. Studies have demonstrated that physicians will incorporate the delivery of non-traditional preventive services such as fluoride varnish applications into their practices and that as a result access to these services will be increased substantially over a system that relies solely on dentists to provide care for infants and toddlers [4]. A series of studies are investigating the effectiveness of preventive oral health services provided in medical offices on dental treatment outcomes, cost effectiveness and the oral health status of children.

Screening and referral services are an important component of the IMB program because of its potential to detect elevated risk and provide early detection of dental caries or other oral health problems. Yet, the impact of this important aspect of the IMB program has not been assessed beyond one validation study of physicians' accuracy in detecting ECC and their self-reported referral practices [5]. The three studies in this dissertation provided an in-depth assessment of the oral health screening, risk assessment and referral aspect of the IMB program. The overall purpose of these studies is to evaluate the appropriateness and effectiveness of screening and referral practices of physicians participating in the IMB program in North Carolina.

This dissertation includes three studies reporting on three different aspects of the screening and referral component of the IMB program. The first and second studies rely on a common dataset that combines Medicaid claims having information on visits to the dentist with physician-completed child oral health risk assessment forms (2000-02) that contain information on child oral health status and physician referral recommendations. Therefore, they provide unique information about dental referrals and their outcome within a medical model for the delivery of preventive dental care. The third study is an analysis of the influence of the IMB program on timeliness of receipt of care for children who had well-child visits in IMB versus non-IMB participating practices. The data for the third study come from years 2004-2006 when the demonstration phase of the program had ended and provides an assessment of program effects from a more stable period of IMB implementation. This concluding chapter briefly reviews the main findings from the three studies, discusses overall limitations and policy implications and provides recommendations for future research.

7.2 Study 1: Predictors of referrals for dental care from a medical office based preventive dental program

This study combined Medicaid claims with physician-completed patient oral health risk assessment records (Encounter Forms, EFs) to assess the appropriateness and predictors of physician referrals to dentists during 2000-2002. Within the risk-based framework adopted for this dissertation, the appropriateness of referrals refers to whether children in need of a referral were indeed provided with a referral by their physician. Appropriateness was assessed by examining the number of children with ECC who were not referred (under-referral). We however could not accurately determine over-referrals because of the lack of complete information on risk factors other than ECC that might contribute to the need for a referral using the risk-based framework. Over-referral also is of less concern to public health than under-referrals because guidelines promoted by the dental profession recommend that all infants be referred for dental care by one year of age [6].

We found evidence of under-referrals by physicians participating in the IMB program, which substantiates findings from at least one other study [7] that reported that physicians have a tendency to under-refer. We concluded that although physicians are able to identify ECC, they likely need further training to enhance their self-confidence in ECC detection and providing the needed referrals to dentists. Further, any attempts to improve under-referrals likely need to be tied to system level changes that encourage and assist practitioners to provide oral health risk assessment services on a more frequent basis.

The second component of this study assessed the predictors of physician referrals for dental care. These predictors were evaluated in the context of the training physicians receive as part of the IMB program. The training uses a risk-based model of identifying children with ECC and referring them to a dentist. This assessment of predictors also was informed by previous studies that have identified factors that are likely to encourage physicians to provide dental referrals [5, 7, 8]. Results indicate that pediatric primary care providers who have received training in oral health risk assessment are strongly influenced by the presence of ECC in their decision to refer a child to a dentist. Results also indicate important differences in predictors for medical practices located in metro and non-metro counties. The probability of referral was higher for children with ECC compared to children without ECC and for those seen in practices in non-metro compared to metro counties. The number of children in the practice with dental caries in the past three months and availability of general dentists in metro counties positively predicted practice-level likelihood of referral. The availability of general dentists in a contiguous county to a non-metro county positively affects the likelihood of referral in non-metro counties. Taken together, these findings suggest that although physicians provide referrals to children who are most in need of dental care, much work needs to be done to increase their ability to provide referrals for all children they identify to have dental needs.

7.3 Study 2: The effect of physician referrals on use of dental care among Medicaid-enrolled preschool age children

Little evidence exists for the role that physician referrals can play in promoting the use of dental care among children with dental needs. This study used the same data as the first study to examine whether, controlling for ECC, physician referrals for dental care can facilitate children's use of dental care. The main conclusion from this study is that physicians' referrals helped facilitate use of dental care for children in need. However, physicians' tendency to under-refer combined with other barriers to referral likely resulted in fewer children using dental services than are in need of care.

We found that the availability of a general dentist in the county where the medical practice is located is associated with children's visits to dentists' offices. However, the number of pediatric dentists did not affect children's use of dental care. The majority of counties in NC do not have a pediatric dentist, whereas most counties have at least one general dentist [9]. Thus, from a policy perspective one will have to look to general dentists in most communities as the first point of contact for primary care physicians involved in oral health risk assessment and referrals. This finding also means that a concerted effort is needed to train and encourage general dentists to become comfortable with seeing preschool age children in their practices. Strategies to address this lack of training and other barriers to dentists' provision of care for young children, especially those from low-income families, are needed.

Findings from this study also lend support to the concept of a dental home. We found that controlling for ECC and referral status, children who had accessed dental care prior to their first IMB visit were able to get dental care sooner, after the physician referral, compared to children who had never visited a dentist prior to their first IMB visit. This association persisted even after controlling for other facilitating factors such as a physicians' referral for dental care.

7.4 Study 3: The effect of a medical office-based preventive dental program on children's access to dental care

The aim of the third analysis was to examine the effect of referrals on access to dental care for children who received well child services in practices participating in IMB compared to practices not participating in IMB. The overall goal of this intent-to-treat analysis was to assess whether the IMB program had any effect on the timeliness of receipt of dental care for children in need of dental services. The premise for this analysis was that, because of their training, providers in IMB practices are likely to have a heightened awareness of ECC and its risk factors, which should increase the likelihood of children with these conditions being identified and referred for dental care.

However, this hypothesis was not supported in our analyses. Instead, we found that participation in the IMB program by a practice at a high level where greater than 30% of WCVs have IMB services provided in them, results in lower dental visit rates for children who received well-child care in those practices compared to practices that never participated in the IMB program. Although contrary to our expectation, this finding does provide some evidence for the preventive effect of the IMB program. Future research however needs to examine the effect of receiving care in IMB practices on dental use with a longer follow-up than the 36-month period used in this study. Extending the follow-up period would allow for a better assessment of the preventive effect of IMB at older ages when the prevalence of tooth decay increases substantially.

Additionally, to further examine the referral effect, there may be value in exploring a different (higher) cut-off for the definition of a high IMB practice. It is possible that the cut-off of >30% of well-child visits in combination with IMB services resulted in the misclassification of many low IMB practices as high IMB practices. If IMB practices that provide a larger ratio of IMB visits to WCV than used in this study to define high-intensity IMB practices are the ones more likely to engage in referrals, then the current analyses would be unable to detect this effect because of being under-powered.

7.5 Limitations

A key limitation of these analyses is that no information on dental disease was available for children who did not have an IMB visit. Therefore, it is not possible to compare the extent of untreated disease in children having IMB visits and those not having IMB visits. The third study would have particularly benefited from the availability of data on ECC, which would have allowed us to better explore the effect of IMB participation on the timeliness of children's receipt of dental care. The three studies in this dissertation also are potentially limited by gaps in Medicaid eligibility with the implication that children could have received dental treatments not recorded in the claims files.

Another limitation in the first two studies in the dissertation relates to the use of child EFs completed by physicians. Initial examination of these forms indicates that they may undercount IMB visits compared to Medicaid claims. However, the match between encounter forms and claims was close to 90%, with most matches occurring for the child's first EF, which should corresponded to the first IMB visit. Therefore, analyses for studies 1 and 2 were restricted to the child's first EF to help control for missing records for any IMB visits. Further, patient EFs were available for only a subset of children who received IMB services statewide, as evidenced by the higher number of claims than EFs. Another study done as part of this dissertation (Appendix B) indicates that physicians have a tendency to complete EFs for children who have ECC or other risk factors [10]. But we were unable to account for the extent to which this would bias our analyses.

The first two studies used data from the demonstration phase of the NC IMB program, a time when physicians participating in the program likely were in the process of developing their oral health risk assessment skills and becoming comfortable with providing IMB services. It is possible that these factors contributed to the high rate of under-referrals found in the first study. Lastly, as indicated in the section that provides an overview of results from the third study, the definition of high and low intensity IMB practices could have resulted in misclassification of practices in that analysis. Although the definition accounts for the volume of WCV occurring in a practice, we used a static three-month average for the cut off to define high and low intensity IMB practices. There might be value in exploring cut offs other than the 30% value that we used to explore the relationship between IMB participation and time to a dental visit

7.6 Policy implications and future research

The analyses in this dissertation contribute to our understanding of the effectiveness of referrals for dental care made by physicians implementing office-based screening procedures. Specifically, these analyses provide a novel assessment of the predictors of referrals, the extent to which children receive dental treatment following referrals, and the reduction in dental visit rates due to the availability of practice participation in IMB.

Although medical practitioners in this study assessed risk and presence of ECC, they apparently need more support and training to provide referrals for all children they identify as having dental needs. Further, an important goal of programs that encourage primary care medical providers to conduct oral health risk assessments and referrals for follow-up dental care is to ensure that children identified as having ECC or those considered to be at elevated risk are able to gain access to a dentist. Future research needs to examine system- and process-level strategies to improve both the appropriateness and the effectiveness of physicians' referral practices. System and process changes such as the use of case managers who help parents navigate the dental care system are likely to aid in gaining access to dental care for their children. Provision of continuing medical education seminars and other means of enhancing the referral process such as through the use of structured referral checklists [11] are possible means for improving the appropriateness and effectiveness of physician referrals.

Attempts to improve the referral process also will need to consider parent characteristics. For example a recent study indicates that low parental literacy is associated with worse asthma care of children, including a greater incidence of emergency room visits and hospitalizations [12]. Thus an intervention that aims to improve the referral process might entail an assessment of the quality of the interaction between the physician and the parent. Evidence continues to accumulate that health literacy and patient-physician communication can play an important role in patient outcomes [13]. It is conceivable that the quality of the interaction between the physician and the parent might influence the parent's ability or motivation to seek dental care for their child. Improved communication may also help address logistical issues such as the high frequency of broken appointments, a common reason given by dentists for not accepting Medicaid-insured patients.

Pediatric primary care practitioners are committed to the problem of ECC and many guidelines and programs are actively engaged in bridging the gap between the medical and dental care settings for young children. Evidence from the current study indicates that physician referrals can facilitate use of dental care by children receiving the referrals. However, physicians tend to under-refer and their referrals result in dental visits for only a small proportion of the children who need to see a dentist. In such a scenario, recommendations that emphasize that all children should receive a referral are likely to have little success in promoting children's use of dental services. Given our limited resources, program successes are more likely to occur with programs that focus on training pediatric primary care providers to identify children most in need of dental care and in developing systems and processes that are likely to enable them to help these children in gaining access to needed treatment services [14]. Further, these initiatives likely will have greater success if they explicitly link physicians with dental practitioners in their communities who are willing to participate in the referral process.

Finally, there is initial evidence to indicate that practice participation in IMB at a high intensity reduces dental visit rates for children when first seen for well child care in those practices. We interpret these findings in the third study, which used an intention-to-treat analysis, to mean that we were better able to detect the effect of caries preventive services provided as part of the IMB program than any effect from the dental screening services. However, the relationship between the referral and preventive effects of IMB should be explored further with a longer follow-up period than 36 months included in this study and with varying definitions for the intensity of IMB participation by practices.

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APPENDIX A

Multiple Imputation of Clustered Dental Caries Data Using a Random Effects Zero-Inflated Poisson (ZIP) Model

A Technical Report

INTRODUCTION

Missing data is a reality in most research studies and researchers have adopted various approaches to deal with this issue. These approaches include complete case analysis, mean imputation, and most recently, multiple imputation. Evidence shows that complete case analysis, which involves deleting observations with the missing information and results in a reduction in the sample size available for analysis can create bias in study results. Mean imputation, which involves calculating the average value of the non-missing observations for a particular variable and substituting this average value for those observations with missing information also generally produces biased variance and covariance estimates [1]. One reason for this bias is that mean imputation reduces the variance in a variable. Multiple imputation (MI) has been demonstrated to produce consistent, asymptotically efficient, and asymptotically normal estimates when data are missing at random, and is increasingly considered the standard approach for addressing the issue of missing data in research studies [1].

Missing data in situations where data represent a naturally occurring hierarchy (e.g., children clustered within classrooms in schools) require special attention, especially when the researcher intends to use hierarchical modeling techniques to analyze such data. It is now recognized that when data are hierarchical, and so are the intended analytic techniques, the imputation model needs to explicitly account for this pattern of clustering [2]. In dentistry, dental caries data are commonly collected either using the DMFS/DMFT index, or as counts of teeth present and counts of decayed teeth. To our knowledge there have been no applications of multiple imputation techniques for imputing clustered dental caries data. The most important characteristic of dental caries data is the highly skewed nature of its distribution in the population, wherein most individuals have a value of zero indicating no disease. Apart from the clustering of values at zero, the counts of teeth with caries generally follows a poisson distribution. Because of these characteristics, none of the built-in routines in most commercially available software including SAS® and Stata®, can be used to impute missing dental caries data that is highly skewed towards zero.

The purpose of this paper is to describe a fairly straightforward process to impute missing dental caries data using a zero-inflated poisson (ZIP) regression model which provides superior fit for dental caries data. We take advantage of the fact that the ZIP model has previously been extended to include random effects in order to account for clustered zero-inflated count data [3]. To our knowledge however, the ZIP random effects model has not been used to impute missing dental caries data.

The Zero-inflated poisson (ZIP) regression model

Count data include data that are either frequency counts of an event, or cases where each count value represents a collection of values. Real-life data that follow a count distribution commonly exhibit overdispersion and zero inflation. Overdispersion refers to situations where the mean for the count variable is less than the variance for that variable. Zero-inflation is the term used to refer to the presence of excess zeros, a situation commonly observed with dental caries data because of the low prevalence of dental caries at the population level. Zero-inflated poisson (ZIP) regression models allow for the modeling of count data with overdispersion as well as zero inflation [4-7]. Previous studies that have used the ZIP model to analyze dental caries data [6, 8] suggest that it provides superior fit for dental caries data, which frequently exhibit an excess of zeros and overdispersion compared to a poisson model.

The ZIP model is a special mixture model having two components. The first component has a fixed value at 0, in this case representing the cases that have zero teeth with caries. The second component is similar to a poisson model, where each numerical value represents one or more values, e.g., the number of teeth with caries with values between 1 and 20 (for primary teeth).

$$\Pr(y \mid x) = \begin{cases} \pi + (1-\pi)e^{-\mu}\dfrac{\mu^{y}}{y!} & \textit{for } y = 0 \\ (1-\pi)e^{-\mu}\dfrac{\mu^{y}}{y!} & \textit{for } y > 0 \end{cases}$$

In this model, y represents the dependent variable (which has a ZIP distribution), and π is the probability of being an extra zero. The term $\mu = x\beta$, where x represents a vector of independent variables and β are their corresponding coefficients. Cases where y=0 can be thought of as representing two groups, where the first group is not part of the poisson process, however the second part is a part of the Poisson distribution, with a mean μ and only taking on values of zero. Cases with $y > 0$ are all considered part of the Poisson process, where $0 < \pi < 1$ to account for more zeros than those allowed under the Poisson assumption ($\pi = 0$), and $\pi < 0$ would indicate that there exists zero-deflation [9]. The covariates (x) included in the two parts may or may not be the same.

ZIP model with random effects

Wang et al. (2000) have extended the ZIP model to account for clustered data by including random effects in the logistic and poisson parts of the ZIP model. The random effects (u, v) are included in the linear predictors (xβ) for both parts of the ZIP model [10]. The covariates appearing in these two parts are not required to be identical. The random effects for the two parts of the ZIP model are considered to be independent and distributed as $N(0, \sigma u1^2 Im)$ and $N(0, \sigma u2^2 Im)$ respectively, where Im denotes an m×m identity matrix.

METHODS

Data

In NC, Medicaid reimburses medical practitioners to provide preventive dental care during well child visits for low-income children ("Into the Mouths of Babes", IMB program). During the demonstration phase (1999-2002), physicians voluntarily completed patient encounter forms (EF) to provide dental information not available in Medicaid claims submitted for reimbursement. A total of 24,403 EFs were available for a study that assessed the predictors and appropriateness of physician referral behaviors. On the EFs, the dental caries variable had the following categories for indicating the number of teeth with decay: 1. None, 2. 1-2 teeth, 3. 3-4 teeth 4. 5-6 teeth, 5. 7-8 teeth, 6. 9-10 teeth, 7. 11-12 teeth, 8. 13-14 teeth, 9. 15-16 teeth, 10 17-18 teeth and 11. 19-20 teeth (see Table 1). Of the EFs available, about 27.2% (N=6638) had missing information on this variable. Because our analysis plan was designed to account for the hierarchy of children clustered within medical practices in NC counties, we developed an imputation model to impute the missing dental caries data taking into account this hierarchy.

Steps in imputation

Briefly, to generate the imputed dental caries data we first estimated a county random effects zero-inflated poisson (ZIP) model using all available observations with non-missing information on dental caries. In this model caries at the child level was modeled as a function of the child's age (age in months, and two quadratic age terms), race (Hispanic or not), percent of child's county population 0-17 yrs. of age living in poverty, and the Health Professional Shortage Area (HPSA) for primary care designation for the child's county (whole, partial or not HPSA). The random effects and coefficients estimated from this model were then used to generate predictions for the dental caries variable for children with missing dental caries. The process was repeated 20 times to generate 20 datasets with complete information on the dental caries variable. We used PROC NLMIXED in SAS® version 9 to carry out all imputations and the SAS code is provided at the end of this document. This process of imputing the data is described in detail in the steps below.

Step 1: Examine whether county random effects are important

In the first step we examined whether physician-identifies caries prevalence in our sample varies across counties, the highest level of clustering in the data. Descriptive statistics for the variables eith non-missing information on caries are provided in Table 2. The estimates from the county random effects Poisson model for the likelihood of having caries among children seen in medical practices with the highest volume of IMB visits per county in North Carolina are provided in Table 3. In this step a Poisson model was employed, and not a ZIP to allow for less time consuming estimation of the parameters. The coefficients from this poisson model were used as starting values in performing the grid search used to estimate the ZIP with county random effects for predictors of dental caries in the second step.

Step 2: Estimate ZIP model with county random effects

In the second step we estimated a ZIP model with county random effects (see Table 4) by regressing dental caries on variables including child's age in months and two quadratic age terms (age square and age cube), an indicator for whether the child is Hispanic or not, percent of the child's county population age 0-17 years living in poverty, the county's classification as either being completely (whole) or partially (partial) designated as a health professional shortage area for primary care (HPSA).

Model to generate the county random effects

Equation 1:

$$\begin{aligned} \mathrm{logit}(\varphi ij) = \xi ij = \ 1/1 + (\exp(-(\alpha 0 + \alpha 1{*}\mathrm{AGEMONEX}_{ij} + \alpha 2{*}\mathrm{AGEMONEXSQ}_{ij} + \\ a3{*}\mathrm{AGEMONEXCU}_{ij} + \alpha 4{*}\mathrm{HISPANIC}_{ij} + \alpha 5{*}\mathrm{PCTPERPOV}_{ij} + \\ \alpha 6{*}\mathrm{HPSAPRIM\_WHOLE}_{ij} + \alpha 7{*}\mathrm{HPSAPRIM\_PARTIAL}_{ij} + u1))) \end{aligned}$$

$$\begin{aligned} \log(\theta ij) = \eta ij = \exp(\beta 0 + \beta 1{*}\mathrm{AGEMONEX}_{ij} + \beta 2{*}\mathrm{AGEMONEXSQ}_{ij} + \\ \beta 3{*}\mathrm{AGEMONEXCU}_{ij} + \beta 4{*}\ \mathrm{HISPANIC}_{ij} + \beta 5{*}\mathrm{PCTPERPOV}_{ij} + \\ \beta 6{*}\mathrm{HPSAPRIM\_WHOLE}_{ij} + \ \beta 7{*}\mathrm{HPSAPRIM\_PARTIAL}_{ij} + u2) \end{aligned}$$

Using the random effects estimated in the above equation, we generate 20 sets of random effects (*u1* and *u2*) by drawing randomly from a uniform normal distribution for these random effects.

Step 3: Generate predictions for level of caries based on estimated random effects

We then use these random effects values as part of equation 1 to generate predictions for the children with missing dental caries data. Each set of *u1* and *u2* values are inserted into this equation for individuals with missing dental caries. If the predicted caries imputation value in the first part of the ZIP model is less than a random number drawn from a uniform normal distribution, then the individual is assigned a value of zero. Alternately, if the imputed value from the first (zero-inflation) part of the model is greater than the randomly drawn number, then the caries prediction is generated using the (second) poisson part of the ZIP model. This prediction generates the poisson probability that the number of teeth with caries is >0, which is then used to calculate the 'level' of dental caries by randomly drawing a value from a poisson distribution. We thus obtain 20 datasets that include 20 values for the imputed dental caries variable for each individual. The distribution of the imputed dental caries variable in the 20 datasets is provided in Table5. For the majority of the sample the value imputed for dental caries was a 0, indicating no disease. The most common maximum value imputed was the category of 7-8 teeth with decay, with only one dataset having an observation with an imputed value of 9-10 teeth with decay. Table 6 provides a comparison of the distribution of the caries variable in the non-imputed, imputed and combined (imputed and non-imputed datasets) for comparison.

Step 4: Using the imputed dental caries variable in a hierarchical model of predictors of dental referral

We use a two-level random intercept model (using three approaches) to investigate the effect of imputing the dental caries variable on the parameter estimates, and the possible bias resulting from the missing caries information. The models are used in a study to investigate the predictors of physician referrals to dentists for children receiving IMB services in medical offices in North Carolina. The first model includes observations with the non-missing caries data and the imputed data. The second model was estimated using only the subset of observations with complete data on the dental caries variable (Model 2) and the third model used the observations without missing dental caries information and the caries status set to zero for those with missing caries information (Model 3). Model 2 therefore examines the association between likelihood of referral and the explanatory variables had a listwise deletion approach been adopted. Model 3 assesses the effect of imputing this information by providing a comparison for a scenario where the belief was that physicians did not complete EFs for children who exhibited no signs of decay.

RESULTS

The distribution of the imputed dental caries data closely resembled the distribution of the variable for observations with the non-missing data. A majority of the observations were imputed to have a value of zero indicating no disease. The largest value imputed was a '5' indicating that the child had 9 or 10 teeth with decay. The hierarchical models 1 and 3 included 24,403 observations from 140 participating medical practices and model 2 included only the non-imputed sample (N=17,766) from 137 practices. A comparison of the regression coefficients across the three models shows that estimates from Models 1 and 3 are very similar, whereas the child-level estimates from Model 2 tend to be bigger than those from the other two models. Further, the estimates from Models 1 and 3 tend to agree in the statistical significance of the explanatory variables more so than with Model 2. The estimated odds ratio for the relationship between ≥1 tooth with decay and the likelihood of referral was 36.2 (95% CI [15.6, 84.2]) when only data with non-missing caries was used (Model 2). When the same model was estimated after including the imputed dental caries data, the odds ratio for the caries variable was estimated to be 15.5 (95% CI [7.5, 31.9]).

CONCLUSION

Clustered dental caries data are a fairly common occurrence in dental public health and oral epidemiological studies. Multiple imputation is increasingly the standard for dealing with missing data when these data are considered to be missing at random. A number of software programs are now available with built-in routines to implement multiple imputation techniques including, SAS®, Stata®, SPSS®, MLWiN®. However, clustered dental caries data have two characteristics that make it a challenge to use these pre-written programs for imputing the missing caries data. First, it is recognized that when data and the intended analyses have a hierarchical structure, the imputation model also needs to account for this hierarchy in generating the missing data [2]. The built-in routines for imputing missing data in most commercially available software do not yet have the capacity to account for hierarchical datasets. The only exception is the software MLWiN®, which currently allows imputation of continuous (but not categorical) variables in a hierarchical setting. The second issue related to dental caries data is that in most studies the distribution of this variable is highly skewed towards zero, because of the overall low prevalence of the disease at a population level. None of the currently available software programs are flexible enough to allow modeling of this skewed distribution. We have provided a fairly straightforward technique that accounts for both, the clustered nature of the data and the excess zeros in imputing clustered dental caries data that is missing at random.

Ignoring missing data can not only reduce the sample available for analysis, but also can lead to biased study results. Using only non-missing data in our study lead to an estimated odds ratio of 36.2 (95% CI [15.6, 84.2]) for the relationship between ≥1 tooth with decay and the likelihood of referral. When the same model was estimated after including the imputed dental caries data, the odds ratio for the caries variable was estimated to be 15.5 (95% CI [7.5, 31.9]). This indicates that ignoring the missing data would lead to an overestimate of the effect of caries on the probability of referral by 57%. Because the prevalence of dental caries at a population level is low, results of our sensitivity analysis where all individuals with missing caries information were assigned a value of 0 lends further strength to our imputation technique. The odds ratio estimate for dental caries in the sensitivity analysis drops to 18.2 compared to 36.2 for the complete case analysis example.

Our results should however be considered in light of two major limitations. First, this study used dental caries information recorded by physicians likely during busy office visits. Nevertheless, the availability of clinical information for individuals enrolled in public insurance programs is a rarity and hence when such information is available, it should be utilized to the extent possible. Second, our procedure to impute dental caries information does not account for cases where other variables also have missing information. However, techniques to impute such information for hierarchical analyses are currently under development [2].

Table 1. Distribution of the physician identified dental caries variable

No. of teeth with caries*	Frequency	Percent
None	16,639	93.66
1 - 2	661	3.72
3 - 4	262	1.47
5 - 6	92	.52
7 - 8	42	.24
9 - 10	24	.14
11 - 12	11	.06
13 - 14	4	.02
15 - 16	14	.08
17 - 18	7	.04
19 - 20	10	.06
Total observations	17,766	100.00

* As identified by the physician at the child's first IMB visit

Table 2. Descriptive statistics for the sample used to impute the missing dental caries data

Variable	Mean or Percent	Std. Deviation	Min	Max
Child's age in months	16.20	7.21	6	36
Child is Hispanic (vs. not)	15.41	.36	0	1
Percent of child's county population 0-17 yrs. of age living in poverty	19.97	4.69	11.3	32.8
Child received a referral for dental care from a physician	3.09	.17	0	1
County designation for Health Professional Shortage Area for primary care (HPSA), Yr. 2000			0	1
No part of county is a HPSA	53.63	.49		
One or more parts of the county designated as HPSA	37.55	.48		
Whole county designated as HPSA	8.82	.29		

Total observations = 17,766

Table 3. County random effects model for likelihood of having dental caries

Variables	Poisson[#]
Constant	-328.896 (303.92)
Child's age in months at exam	.092** (.00)
Child's race (vs. White)	
American Indian	.105 (.21)
Asian	.042 (.46)
Black	-.120 (.09)
Hispanic	.548** (.10)
Other	.002 (.20)
Type of practice where IMB visit occurred	
Health Department	.035 (.20)
Family Practice	.501 (.41)
Pediatric Practice (Ref)	
Child lives in same county as the practice where IMB visit occurred vs. No	-.059 (.09)
At least one pediatric/ general dentist (who sees young children) present in child's county during 2000, 2001 & 2002 vs. none	-0.090 (0.11)
Water fluoridation status of county	
% of population on Public Water System (PWS) receiving fluoride (vs. ≥ 75%)	
0-24	0.075 (0.21)
25-74	0.104 (0.15)

[#] Dependent variable – # teeth with caries (Range 0-10)
[**] Significant at $P \leq .001$, [*] Significant at $P \leq .05$

Table 3. County random effects model for likelihood of having dental caries, contd.

Variables	Poisson[#]
Percent of child's county population enrolled in Medicaid	-.749 (.94)
Rural-Urban Classification for child's county	
(vs. Central or fringe counties of metropolitan areas of 1 million pop or more)	
Counties in metropolitan areas of 250,000 - 1,000,000 pop	.381 (.24)
Counties in metropolitan areas of less than 250,000 pop	.298 (.26)
Urban population of 2500-20,000 or more, adjacent or not adjacent to a metropolitan area	.442 (.26)
Urban or rural population of ≤ 19,000 adjacent or not adjacent to a metropolitan area	.264 (.25)
First year-month when practice started doing IMB (according to claims)	.002 (.00)
Number of observations	15,297
Number of counties (the largest practice per county)	64
Log likelihood	-3227.4482
Proportion of the total variance contributed by the practice county-level variance component (Alpha/ Rho)	.293[**] (.08)

[#] Dependent variable – # teeth with caries (Range 0-10)
[**] Significant at $P \leq .001$, [*] Significant at $P \leq .05$

Table 4. Zero-inflated Poisson with county random effects to predict number of teeth with caries

Variables	Estimate	Std. Error	t value	Pr > t
Caries =0				
Intercept	3.198	.537	5.96	.05
Child's Age				
Age (0 through 36 months)	.0589	.0773	.76	.4478
Age square	-.00796	.00387	-2.06	.0435
Age cube	.000126	.00006	2.09	.0404
Child is Hispanic (vs. not)	-.595	.091	-6.57	<.0001
% of County population 0-17 yrs. of age living in poverty	-.00547	.01672	-.33	.7444
County designation for Health Professional Shortage Area for primary care (HPSA), Yr. 2000				
Whole county designated as HPSA vs. No part of county is a HPSA	.0448	.1637	-.27	.7850
One or more parts of the county designated as HPSA vs. No part of county is a HPSA	.169	.116	1.46	.1489
Variance of level 2 (county) random effect	**.389**	**.103**	**3.78**	**.0003**
Caries >0				
Intercept	.173	.403	.43	.6694
Child's Age				
Age (0 through 36 months)	-.0286	.0575	-.50	.62
Age square	.00375	.00281	1.34	.1857
Age cube	-.00007	.00004	-1.55	.1264
Child is Hispanic (vs. not)	.01028	.06877	.15	.8816
% of County population 0-17 yrs. of age living in poverty	-.0274	.0112	-2.46	.0166
County designation for Health Professional Shortage Area for primary care (HPSA), Yr. 2000				
Whole county designated as HPSA vs. No part of county is a HPSA	-.0336	.1193	-.28	.7791
One or more parts of the county designated as HPSA vs. No part of county is a HPSA	.0831	.0824	1.01	.3166
Variance of level 2 (county) random effect	**.1006**	**.0326**	**3.09**	**.0029**

Number of observations = 21,777

Table 5. Distribution of the imputed dental caries variable in the 20 datasets

Imputed data set	None		1 - 2		3 - 4		5 - 6		7 - 8		9 - 10	
	Number of teeth with caries											
	N	%	N	%	N	%	N	%	N	%	N	%
1	6560	98.84	58	.87	13	.2	5	.08	1	.02	0	0
2	6545	98.61	61	.92	26	.39	5	.08	0	0	0	0
3	6570	98.99	50	.75	13	.2	4	.06	0	0	0	0
4	6554	99.75	60	.9	20	.3	2	.03	1	.02	0	0
5	6580	99.14	37	.56	16	.24	4	.06	0	0	0	0
6	6530	98.44	71	1.07	28	.42	5	.08	3	.05	0	0
7	6544	98.92	67	1.01	23	.35	2	.03	1	.02	0	0
8	6544	98.73	68	1.02	17	.26	7	.11	1	.02	0	0
9	6547	98.69	68	1.02	18	.27	2	.03	2	.03	0	0
10	6530	98.56	69	1.04	29	.44	7	.11	2	.03	0	0
11	6555	98.86	62	.93	13	.2	5	.08	1	.02	1	.02
12	6562	98.68	57	.86	15	.23	2	.03	1	.02	0	0
13	6554	98.76	59	.89	17	.26	6	.09	1	.02	0	0
14	6560	98.43	55	.83	17	.26	5	.08	0	0	0	0
15	6544	98.57	63	.95	24	.36	5	.08	1	.02	0	0
16	6518	98.75	82	1.24	31	.47	6	.09	0	0	0	0
17	6536	98.83	73	1.1	19	.29	8	.12	1	.02	0	0
18	6544	98.95	66	.99	20	.3	6	.09	1	.02	0	0
19	6556	98.94	57	.86	18	.27	6	.09	0	0	0	0
20	6560	98.70	59	.89	13	.2	3	.05	2	.03	0	0

* Total observations = 6,637

Table 6. Comparison of the distribution of the dental caries variable in the imputed, non-imputed and combined datasets

Number of teeth with caries	Non-imputed only (N = 17,766)		Imputed only (Average of the 20 datasets, N = 6,637)		Imputed and non-imputed combined (N = 24,403)	
	N	**%**	**N**	**%**	**N**	**%**
None	16,639	93.66	6550	98.68	23189	95.02
1 or 2	661	3.72	62	.94	723	2.96
3 or 4	262	1.47	20	.29	282	1.15
5 or 6	92	.52	5	.07	97	.40
7 or 8	42	.24	1	.01	43	.18
9 or 10	24	.14			24	.10
11 or 12	11	.06			11	.05
13 or 14	4	.02			4	.02
15 or 16	14	.08			14	.06
17 or 18	7	.04			7	.03
19 or 20	10	.06			10	.04

Table 7. Comparison of results for the two-level random intercept model for the likelihood of referral for dental care across imputed and non-imputed datasets

	Model 1 Imputed + non-imputed data, N=24,403 children in 140 medical practices		**Model 2** Non-imputed data only, N=17,766 children in 137 medical practices		**Model 3** Non-imputed & Caries set to 0 for imputed data, N=24,403 children in 140 medical practices	
VARIABLE DESCRIPTION	**β**	**S.E.**	**β**	**S.E.**	**β**	**S.E.**
Child-level characteristics						
Constant	–4.09***	.63	–4.88***	.77	–4.07***	.62
Child's age in months at IMB visit	.185***	.033	.221***	.040	.172***	.033
Child's age^2	–.00262***	.00076	–.003**	.001	–.002**	.001
Child is of a minority race (vs. white)	.0947	.0902	.06	.13	.08	.11
Child is male (vs. female)	.083	.109	.04	.11	.09	.09
≥1 teeth with decay (vs. none)	2.74***	.37	3.59***	.43	2.90***	.37
Quarter in which IMB visit occurred (vs. Oct'02-Dec'02)						
Jan'01-Mar'01	.57	.38	.53	.42	.58	.37
Apr'01-Jun'01	–.19	.21	–.29	.23	–.22	.21
Jul'01-Sep'01	–.25	.19	–.29	.20	–.28	.19
Oct'01-Dec'01	.06	.17	–.03	.18	–.004	.169
Jan'02-Mar'02	.52**	.15	.11	.18	.53**	.15
Apr'02-Jun'02	.18	.16	–.39*	.19	.25	.16
Jul'02-Sep'02	–.19	.17	–.20	.19	–.16	.17
% Population on the Public Water System in child's county receiving fluoridated water (vs. ≥ 75%)						
0-24%	–.01	.23	.43	.26	–.01	.23
25-49%	–.37	.24	–.06	.26	–.44	.24
50-74%	–.61**	.21	–.54*	.24	–.61*	.21

*** Significant at $P \leq .0001$, ** Significant at $P \leq .001$, ** Significant at $P \leq .05$.

Note: Child's age, age^2, male sex and minority race are centered around the practice mean in the child-level model

Table 7. Comparison of results for the two-level random intercept model for the likelihood of referral for dental care across imputed and non-imputed datasets, contd.

	Model 1 Imputed + non-imputed data, N=24,403 children in 140 medical practices		**Model 2** Non-imputed data only, N=17,766 children in 137 medical practices		**Model 3** Non-imputed & Caries set to 0 for imputed data, N=24,403 children in 140 medical practices	
VARIABLE DESCRIPTION	**β**	**S.E.**	**β**	**S.E.**	**β**	**S.E.**
Aggregated practice-level variables						
Average age of Medicaid enrolled children seen in practice	.061**	.019	.085**	.024	.06*	.02
Average difference in likelihood of referral for male Medicaid-enrolled children across practices in a given month (vs. female)	–.49	.36	–.30	.44	–.50	.36
Average difference in likelihood of referral for minority race Medicaid enrolled children across practices in a given month (vs. white)	–.35**	.12	–.16	.14	–.36*	.12
Average number of children with ≥1 tooth with cavities seen the practice in month of IMB visit (vs. 0 cavities)	1.227	1.013	.78	1.15	1.07	.98
Practice characteristics						
Type of setting where IMB services were provided (vs. pediatric practice)						
Health department	.26	.15	.02	.17	.29*	.15
Family medicine practice	–.142	.202	–.05	.23	–.16	.20
Total IMB visits per practice from date of 1st IMB claim through month of current IMB visit.						
Log (IMB visits)	–.246***	.051	–.22**	.065	–.25***	.05

*** Significant at $P \leq .0001$, ** Significant at $P \leq .001$, ** Significant at $P \leq .05$.

Table 7. Comparison of results for the two-level random intercept model for the likelihood of referral for dental care across imputed and non-imputed datasets, contd.

	Model 1 Imputed + non-imputed data, N=24,403 children in 140 medical practices		**Model 2** Non-imputed data only, N=17,766 children in 137 medical practices		**Model 3** Non-imputed & Caries set to 0 for imputed data, N=24,403 children in 140 medical practices	
VARIABLE DESCRIPTION	**β**	**S.E.**	**β**	**S.E.**	**β**	**S.E.**
Log (IMB visits) * Mean number of children with ≥1 tooth with caries seen in practice through the month of a child's IMB visit	.129	.066	.084	.078	.138*	.065
Practice County characteristics						
# Pediatric dentists/ 10,000 population age 0-17 years	–.21	.14	–.26	.16	–.21	.14
# General dentists per 10,000 population	.067	.047	.109*	.054	.068	.047
# General dentists/ 10,000 population in largest contiguous county to practice	.075*	.036	.081	.044	.074*	.036
Age 0-17 population in county/ 10,000 population	.015	.017	.009	.019	.015	.017
# Medicaid eligibles/ 10,000 pop.	–.00085*	.00031	–.00108*	.00037	–.00086	.00031
Practice is in non-metro (vs. metro) area	.47**	.13	.20	.15	.49**	.13
Level-2 (practice-level) random intercept variance	**.0096**	**.0075**	**.007**	**.010**	**.0075**	**.0075**

*** Significant at $P \leq .0001$, ** Significant at $P \leq .001$, ** Significant at $P \leq .05$.

SAS code

Code to estimate the random effects ZIP model using the data with non-missing dental caries information

```
proc sort data=aim1b; by CNTYID_PR; run;

proc nlmixed data=aim1b qpoints=15;

/* Enter starting values for grid search */
parms   a0= 3.1999 a1= .05747 a2= -.00796 a3= .000126 a4= -.5660 a5= -.00459
        a6= -.00979 a7= .1397 s2u1= .3820
        b0= .1660 b1= -.03127 b2= .003687 b3= -.00007 b4= .05623 b5= -.02372
        b6= -.07242 b7= .05164 s2u2= .06351;

linpinfl= a0 + a1*AGEMONEX + a2*AGEMONEXSQ + a3*AGEMONEXCU + a4*HISPYES +
          a5*PCTPERPOV + a6*HPSAPRIM_WH + a7*HPSAPRIM_PAR + u1;
infprob= 1/(1+exp(-linpinfl)); /* inflation probability for zeros */

lambda= exp(b0 + b1*AGEMONEX + b2*AGEMONEXSQ + b3*AGEMONEXCU + b4*HISPYES +
          b5*PCTPERPOV + b6*HPSAPRIM_WH + b7*HPSAPRIM_PAR + u2);

   if CARIES = 0 then prob = infprob + (1-infprob)*exp(-lambda);
   if CARIES = 0 then loglike = log(prob);
      else loglike = log((1-infprob)) + CARIES1*log(lambda) -lambda -
            lgamma(CARIES1+1);

   model CARIES ~ general(loglike);
   random u1 u2 ~ normal([0,0], [s2u1, 0, s2u2]) subject = CNTYID_PR
   out=pois.ebayesu1u2;
run;
```

Code to generate predictions for the missing dental caries variable

```
%macro impute (output, seedval1, seedval2, seedval3);
 data &output (keep=IDNEW CARIES1 AGEMONEX);
  set aim1b2;
   seed=&seedval1;
    retain u1 u2;
     by CNTYID_PR;
        if first.CNTYID_PR then do;
              u1=sqrt(.3888)*rannor(seed);
              u2=sqrt(.1006)*rannor(seed);
            end;

/* insert code for computing linear predictors for each observation */
      seed=&seedval2;

     linpinfl = 3.1979 + .05898*AGEMONEX + 2*(-.00796*AGEMONEX) +
                 3*.000126*AGEMONEXSQ -.5953*HISPYES -.00547*PCTPERPOV -
                 .04483*HPSAPRIM_WH + .1686*HPSAPRIM_PAR + u1;
```

```
      infprob= 1/(1+exp(-linpinfl)); /* inflation probability for zeros */

      if ranuni(seed) < infprob then CARIES =0;

else do;

    seed=&seedval3;

      lambda= exp(.1729 - 0.02864*AGEMONEX + 2*.003753*AGEMONEX +
                  3*(-.00007*AGEMONEXSQ) + .01028*HISPYES -.02744*PCTPERPOV -
                  .03358*HPSAPRIM_WH + .08311*HPSAPRIM_PAR + u2);

      CARIES =ranpoi(seed, lambda); /* code to generate the poisson count */
 end;

 format CARIES CAVFORM.;
 run;
%mend impute;
```

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APPENDIX B

Agreement between structured checklists and Medicaid claims for preventive dental visits in primary care medical offices

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ABSTRACT

Background

During the demonstration phase (2000-2002) of North Carolina's (NC) fluoride varnish program for Medicaid-enrolled children, physicians voluntarily completed patient encounter forms (EFs) to provide dental information not available in Medicaid claims submitted for reimbursement. This study assesses the agreement on frequency of preventive dental visits in these two data sources to determine their usefulness for program evaluation.

Methods

The EF data were linked with NC Medicaid claims using patient identifiers and agreement on visits was measured using weighted kappa statistics. A multinomial logit model with practice-level clustering was used to examine predictors of the likelihood of a match between EFs and claims.

Results

In total, 34,171 matches were found between 41,252 EFs and 40,909 claims, representing 82.8% of EFs and 83.5% of claims. Agreement on visit frequency was 56% overall (weighted kappa=.66). Pediatric practices provided the majority of visits (82.4%) and matches. Increasing age of child and residence in the same county as the medical practice increased the likelihood of a match. Compared to pediatric practices, family physician practices were more likely to have unmatched EFs than matched EFs and claims.

Conclusions:

Both patient records and claims can have gaps, but insurance claims are the most complete dataset for assessing preventive dental visit frequency. It is not surprising that voluntarily completed EFs were missing for many children. It is likely that a large proportion of the

17% of EF visits that were not matched to claims reflect actual visits that were not billed for some reason. However, the match rate of 82.5% shows that multiple data sources can be combined to evaluate the effectiveness of preventive programs.

INTRODUCTION

Large computerized administrative databases such as those derived from insurance claims are widely used to study healthcare use and related costs [1-3] , healthcare outcomes [4] and most recently, quality of care and patient safety [5]. However, administrative data lack information important for some types of observational studies, such as those requiring patient-level risk factors, and the reliability of available diagnostic information may be limited. Patient medical records can provide important information on risk factors, disease status and outcomes not available in claims files, so linking claims with medical records or other sources of patient information can increase the richness of available data [6]. A key methodological issue in using these multiple data sources for patient information is the feasibility of linking information contained in these different data sources and the resulting benefits to research and public health practice.

Agreement between administrative claims data, patient records and other data sources has been studied extensively in medicine [1, 4, 7-12]. Most of this research has focused on the validity of claims information, with the conclusion that, in general, claims can accurately represent medical procedures and visits and thus can be used to study large populations. Although a moderate to high level of agreement is observed between claims and medical records, another general conclusion from this research is that important information occurs in one source and not the other, particularly for some preventive services such as immunizations, and thus neither can be considered as a gold standard [1, 7]. Thus, another important conclusion from these studies is that information about the provision of health care services is more accurate when administrative data are supplemented with information from other sources [8, 10].

Clinical practice guidelines have become an important part of initiatives to help ensure that patients receive care that is safe and effective. Dissemination of these guidelines often is accompanied by tools to help ensure their implementation in practice. Structured checklists that correspond to important aspects of the guidelines and are to be used by providers during patient care are a common tool for these purposes because of their demonstrated effectiveness in some areas of care [13]. These checklists, which provide information about the patient's condition and its management, could be another source of information about patients that could enhance administrative databases. This information could be particularly useful because it is based on scientific evidence and standards of care, and is recorded according to a structured format.

The linkage of administrative data with information generated by quality improvement tools, such as checklists, is an extension of studies examining the linkage of administrative data with medical records, but is an under developed area of research. Medical records have been linked to claims to determine the feasibility of using claims for studying guideline adherence, but to our knowledge, agreement between guideline checklists, a very specific part of the medical record, and claims has not been studied specifically for determining the value of using checklists to supplement claims [1]. Claims have been used to a limited extent to study the provision of dental services, but no studies have linked claims with practice guidelines [2]. In this study we explore the feasibility of linking clinical care checklists with Medicaid (billing) claims for a preventive dentistry program based in primary care medical offices.

The North Carolina Medicaid program began encouraging non-dental healthcare practitioners to provide pediatric preventive oral health services in 2000 in response to the increasing prevalence of an already high level of dental disease in young, low-income children, and severe limitations in their access to dental care. Physicians can be reimbursed for oral health risk assessment, parent counseling, topical fluoride therapy, and needed referrals to dentists when provided for children younger than 3 years of age [14]. Services provided in this program are aligned with guidelines provided by the American Academy of Pediatrics for oral health care (AAP, 2003). Several other states also have instituted similar programs for their Medicaid enrolled children.

As part of the North Carolina preventive dentistry program, known as "Into the Mouths of Babes (IMB)", participating providers are asked to complete a structured sheet for each patient visit, referred to in this paper as the "encounter form", which records results of their assessments of risk for dental diseases and the preventive dental services provided for each child. Information in the completed forms is used by physicians to guide care decisions during the child patient encounter, and becomes a permanent part of patients' records. In the current study, we examine agreement on preventive dental visits between encounter forms produced as part of the child visit and administrative claims files generated through reimbursement of physicians for services provided to Medicaid-enrolled children.

The specific objectives of the study are twofold. First we assess the feasibility of matching preventive dental checklists (encounter forms) to Medicaid claims produced as part of the IMB program. Second, we assess agreement on the frequency of preventive dental visits in these two data sources, and identify those characteristics of the child and the medical practice in which the visit occurred that are associated with agreement in the two data sources. The results will add to knowledge about the significance of using administrative claims with known advantages for studying large, diverse populations in combination with structured checklists, often seen as an important part of clinical practice guidelines. In particular, this study provides insights into research methods that can be used to study the adoption of preventive dental services by healthcare providers who usually do not provide dental care and their adherence to recommended guidelines for provision of these services. Physicians' referrals to dentists for needed follow-up care represents an important application of guidelines because individuals are now getting more and more of their care in multiple settings.

METHODS

NC Medicaid enrollment and claims files were matched with patient records of preventive dental visits (encounter forms, EFs) using individual-level information in both data sources. We compared preventive dental visits in the linked dataset for those medical practices with a total of at least 10 EFs and claims for dental visits. We chose this threshold to eliminate practices that participated in continuing medical education (CME) to make them eligible for reimbursement from Medicaid, but never fully adopted the practice.

NC Medicaid enrollment and claims files

The enrollment and claims files (hereafter referred to as claims) provide information on all children birth through 6 years of age who were enrolled in the NC Medicaid program from July 1999 through September 2003. The files include the child's name, date of birth, Medicaid identification number (ID), race, sex, and a record of the preventive dental services provided to children by participating medical practitioners (pediatricians and family physicians) in NC during 2000 through 2002. In order to receive any reimbursement from

NC Medicaid for providing preventive dental services in an office visit, medical practitioners are required to provide each of the following three services: (1) screening the child for dental disease and referral to a dentist if needed, (2) topical fluoride therapy for the child's teeth, and (3) parent education about preventive oral health care practices for their child. According to NC Medicaid policy for the period for which data are available, participating providers could submit claims for preventive dental services provided during well-visits or other office visits for a maximum of 6 visits before the child's third birthday, and a provider could be reimbursed for one preventive dental visit every 90 days.

Preventive dental patient records (encounter forms, EFs)

Physicians who provided preventive dental services to children in the IMB program were trained to document their risk assessments and services through completion of an encounter form at each visit in a two-hour continuing medical education course enhanced with a toolkit and internet-based materials. The risk assessment generally followed recommendations provided in professional guidelines [15, 16]. During the demonstration phase of the program (1st January 2000 through 31st December 2002) the forms were completed in duplicate and one copy mailed to the project office for data entry. Apart from the information available from the claims, the EFs also include: the child's dental disease and risk status, parental reports about feeding and oral hygiene practices, and whether the child was referred to a dentist or not. Most children could have up to 6 EFs, 1 for each of the total of 6 reimbursable visits allowed by the NC Medicaid program, but they could have more if non-reimbursable visits were provided by a single practice or through multiple providers.

Linkage of data files

The data linkage process for this study involved two steps. In the first step, the encounter form (EF) database was linked to NC Medicaid enrollment information using the child's name, date of birth and Medicaid Id. In the second step, the child's Id and date of visit were used to match preventive dental visits recorded in the EF with a similar visit recorded in the claims database. Figure 1 provides a summary of this process, which is described in more detail below.

Step 1: Linkage of EF with Medicaid enrollment information

The two commonly recommended method for merging data from two data sources when a common identifier is incomplete or unavailable it to either use a merge algorithm based on data linkage theory (probabilistic method) [17], or to use a set of variables (e.g., name, data of birth, sex, county of residence, patient identifier when available) that is common to both data sets (deterministic approach) [7, 18]. Roos and colleagues found that the deterministic approach can be used successfully to match more than 95% of medical procedure records recorded in multiple data sources [9]. We therefore adopted a deterministic approach to match EFs to claims to account for EFs with missing, incomplete or inaccurate Medicaid ID, by creating merge variables on the EFs and claims datasets using various combinations of the child's full name, date of birth and Medicaid ID. We used payment revenue codes from the Medicaid claims to construct a preventive dental visit indicator comparable to the one available in the EFs.

Further, as mentioned previously, we ensured that each child could only have up to a maximum of 6 possible visits before his or her third birthday, and that there was a 90-day gap between multiple visits for the same child. Of the 31,024 unique IDs from the EF database, 29 IDs (representing 35 EF) could not be found in the claims. After excluding these 29 children, a total of 41,666 preventive dental visits were found in the claims file for 27,960 children (1.5 visits per child).

We also ensured that the visit dates recorded in the EFs and claims did not precede the date when the practice started providing the preventive dental services. Finally, of the 194 medical practices, 25 practices with only claims and no EF; and 16 practices that had fewer than 10 claims or EF during the study period were deleted to obtain the 153 medical practices included in this study. This resulted in 41,252 EFs for 30,606 children and 40,909 claims for 27,607 children being available to be matched.

Step 2: Match between EF visits and claim visits

To assess the match on preventive dental visits between EFs and claims data, we first generated a sub-sample of 'perfect matches' based on perfect agreement on the child's Id and date of visit between the EF and claims databases. Because physicians can be reimbursed for services only once in 90 days, it is possible for non-matches on visits within that time frame to occur due to errors in recording visit dates. Therefore, in the second step, we used the criteria that the claim service date could occur either 89 days before or after the exam date recorded on the EF to generate the second category of 'approximate matches.' This rule would require the claim visit date to be within a three-month window of the visit date recorded on the EF. Using the 89-day criteria, we found 16 instances of more than one claim and 7 instances of more than one EF for the same visit. After retaining the EF visit with the closest matching claim visit, the remaining observations were deleted because they represented multiple visits within the same three-month period. The remaining visits in the EFs and claims databases, after identifying the perfect and the approximate matches were assigned to the non-matches, i.e., either as unmatched EFs or unmatched claims.

Data Analysis

Overall agreement on the number of preventive dental visits between EFs and claims was assessed using percent agreement and weighted kappa (k) statistics [19]. A multinomial logit regression model was estimated to investigate correlates of a record being classified as a match (either being a perfect or an approximate match) versus being an unmatched EF or unmatched claim. Standard errors in the model were adjusted for the clustering of observations within medical practices.

The regression model controlled for child and medical practice characteristics taken, with the exception of a measure of rurality, from Medicaid files. Child characteristics included, the child's age (in months centered at the mean for the sample, 16.5 months), sex, race (American Indian, Asian, Black, Hispanic, Other or White), and whether the child resided in the same county as the medical practice where care was received. Practice characteristics included, type of primary care practice (health department, family physician, pediatrics), the intensity of participation in the preventive dentistry program (defined based on number of preventive dental visit claims per month per county from Jan. 2000 through December 2002), urban-rural classification for the county (7 categories ranging from central or fringe counties of metropolitan areas with $\geq$ 1 million population to counties with populations of 2,500 to 19,999 not adjacent to a metropolitan area) [20], and the first month and year in which the practice started providing preventive dental services to Medicaid patients (divided into quarterly intervals). All analyses were conducted using SAS® version 9 (SAS, Cary, NC, USA) and Stata® version 9 (Stata Corp., College Station, TX, USA). The study was approved by the University of North Carolina at Chapel Hill Institutional Review Board.

RESULTS

Descriptive results for the match on preventive dental visits

The study population included Medicaid-enrolled children (birth through 35 months of age) with one or more preventive dental visit/s during 2000 through 2002 in 153 primary care medical practices that completed 10 or more claims and preventive dental patient records. In total, 34,171 matches were found between the 41,252 EFs and 40,909 claims, representing 82.8% of total EFs and 83.5% of claims (see Figure 2). Seventeen percent of EFs and 16.5% of claims did not have corresponding records in the claims and EFs, respectively. The number of visits per child was 1.5 for the claims, and 1.4 for the EF, and 87% of children had at least one match. In cases where there was more than 1 EF for a child, the EF representing the first visit was found to match to a corresponding claim more often. Overall, there was 56% agreement on number of visits between EFs and claims (weighted kappa = .66).

Of the 34,171 matches, 33,458 (97.9%) were perfect matches where the date of visit matched exactly in the two data sources. An additional 713 (2.1%) were approximate matches where the date of visit recorded on the claim occurred within 89 days before or after the date recorded on the EF for that child. For the majority of the 713 approximate matches, the date recorded on the EF occurred upto three days prior to the visit recorded on the respective claim. A total of 7,081 EFs and 6,738 claims were classified as non-matches using the 89-day rule.

Overall, about 71% of the observations at the practice level comprised of matched EFs and claims, and there were more unmatched EFs (N=7,081) than unmatched claims (N=6738). In considering practices individually, 71.5% of practices had at least one instance of a match between an EF and a claim, and 14% of practices each had at least one instance of having unmatched EFs with no corresponding claims or vice versa.   If a practice had at least one instance of a match between EFs and claims, 71.9% of its observations were those where EFs and claims matched.

Pediatric practices provided the majority of visits (82.4%). At the practice level, of all observations that matched, 71.8% came from pediatric practices followed by health departments (70.7%) and family physician practices (59.4%). Health departments and family physician practices provided 11.7% and 5.9% of the IMB visits, respectively. Family physician practices had more unmatched EFs (30.8%) than either health departments (20.7%) or pediatric practices (13.1%).

Predictors of a match between EFs and claims on preventive dental visits

Results of the multinomial logit model are presented in Figure 3. Of the three outcomes, i.e., unmatched claims (C), unmatched EF (E) and matched claims and EFs (M), match is the comparison group. Therefore, the M’s in Figure 3 are stacked on top of one another. The horizontal position of outcome categories (C and E) depicts the relative magnitude of the risk ratios associated with either of these outcomes compared to the match category. For ease of interpretation, only results that are significant for at least one of the two comparisons are displayed in the Figure. Where there is a lack of statistical significance between two outcomes for a particular predictor variable, either the “C” or “E” is included in a box with the “M” indicating that they are “tied together” [21]. Refer to Appendix A for a table that presents the complete output for the multinomial logit model.

Family physician practices were 2.3 times more likely to have unmatched EFs and 1.6 times more likely to have unmatched claims relative to a match than pediatric practices. Children residing in the same county as the medical practice were less likely to have EFs unmatched than a match. Practices located in urban counties with a population of 20,000 or more were more likely to have unmatched claims than a match. Practices that started providing preventive dental services during the last calendar quarter of 2002 had fewer unmatched claims compared to those that began in 2000 and 2001.

Older children were less likely to have either unmatched claims or unmatched EFs than younger children. Asians, Black, and Hispanic children were more likely than white children to have EFs unmatched, whereas other race children were more likely to have both EFs and claims unmatched.

DISCUSSION

In this study we explore the feasibility of linking clinical care checklists with Medicaid (billing) claims for a preventive dentistry program based in primary care medical offices. Results from this study indicate that both patient encounter forms and Medicaid claims data are important sources of information on preventive dental visits for children receiving these services. However, each data source in and of itself likely provides incomplete information about the receipt of these services. Nevertheless, similar to studies in other fields, we found that it is possible to combine provider records and Medicaid data even in the absence of one or more person-level identifiers with a reasonable degree of accuracy [18]. Of the available EFs, we were able to identify about 90% of children in the enrollment file using only the child's Medicaid ID. Almost all of the remaining EFs were identified using a combination of the child's name, date of birth, and parts of the ID when available.

Overall, more visits were recorded in the EFs database than in the claims. However, the number of EFs per child was lower than the number of claims available for each child in this study. This result is to be expected because of the financial incentive associated with submitting claims, and likely indicates that claims may be a better source of information for establishing patterns of use of preventive dental services over time and assessing the long-term cost-effectiveness of this intervention. Completion of EFs on the other hand likely represents added paperwork for the provider, particularly when copies had to be mailed to the project office. Both of these reasons could contribute to why we found fewer children with two or more completed EFs. However, EFs provide dental disease related information and are therefore an important source, for example, to assess the extent to which physicians are using a risk-based approach to referring children to the dentist. EFs also are important as they can provide information on physicians' completeness of dental risk assessment procedures as part of the preventive dental visit, information that may not be available from the claims data.

We found good agreement on overall visits in the analytical dataset, suggesting that patient records can supplement information from Medicaid claims. The category of 'approximate' matches requires special attention. We were able to achieve a 2% increase in the matches by broadening the window (from 0 to 89 days) around the date of the EF visit within which a claim visit could occur. A majority of the claims visits among the approximate matches were those that occurred after the EF visit date. This is to be expected, because claims for services provided are likely to be submitted after the visit, the time when the EF is completed. However, we found a small proportion of claims that actually preceded the EF visit, with the majority being within three days of the EF. These are likely to be errors in recording the date on the EF. Nevertheless, for the handful of claims that had dates as early as 50 days prior to the EF it is unclear whether these were errors or cases where two different providers within the same practice saw the same child on separate occasions. Our approach in such cases was to retain the claim with a visit date that was closest to the EF visit date within the 89-day window.

The multinomial regression model allowed us to assess the correlates of finding a match between EFs and claims. The higher likelihood of a match for older children suggests that behavioral factors or presence of dental disease (which tends to increase with age) might influence completion of dental health records by physicians. Given that pediatric primary care providers have a limited amount of time in which to provide well-child checkups and anticipatory guidance, it is conceivable that paperwork beyond that needed for follow-up care or for reimbursement of services may go uncompleted. In such a scenario, providers may be more likely to complete patient records for children who have signs of dental decay or are considered to be at high risk for future disease in keeping with a risk-based approach to the provision of preventive dental services.

Pediatric practices were more likely to have EFs and claims that matched to each other than family physicians. An aim of this study was to explore the possibility of supplementing claims data with medical provider records for a Medicaid-enrolled child population. It is likely that claims that remained unmatched were actual visits where EFs were not completed because of provider busyness or the shortage of staff to help with the needed paperwork. However, we also are aware that during the early implementation phase of the preventive dental program some family physician practices experimented with adoption longer than pediatric practices by completing EFs without submitting claims, which may account for their unmatched EF.

Practices that started providing preventive dental services in the last quarter of 2002 compared to the previous years were more likely to have completed EFs for the claims they submitted for reimbursement. The match between claims and EFs improved over time and is likely reflective of learning that took place on part of the individuals involved in training medical practices to adopt the provision of preventive dental services as part of the services offered in their setting.

There are several limitations of this study that are worth noting. Because of its observational nature, findings from this study should be interpreted with caution. Providers were asked to voluntarily complete encounter forms for all children during the demonstration phase of the North Carolina preventive dentistry program. Further, because of the nature of the available data, we are limited in only having access to practice-level and no provider-level information. Therefore, if some providers in a medical practice were more diligent in completing patient records than others in the same practice, we would be unable to identify those providers individually. As indicated from our examination of dates of visits recorded in the claims in the group of approximate matches, some of these claims could possibly represent multiple visits to separate providers within a three-month period. However, in such cases, we selected the date for the claim that was closest to the date noted on the encounter form, which likely reduced the bias in our results. The 29 cases where the child's Medicaid Id as recorded in the enrollment file was not found in the claims database likely represents errors in recording the child's Id or possible lapses in Medicaid eligibility records.

In summary, insurance claims may be the most complete data source for assessing preventive dental visit patterns in the medical primary care setting. However, claims lack important patient-level disease information and may be incomplete for health departments and family physician practices, which are important healthcare settings for Medicaid clients. In contrast, patient encounter forms provide important dental disease information, but are more likely to be complete and to agree with claims for the child's first preventive dental visit. Results from this study suggest that combining claims with patient records is likely to improve the evaluation of public health measures designed to increase access to pediatric preventive dental care.

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Figure 1. Process of matching patient encounter forms to Medicaid claims data

Patient Encounter Forms (EFs)

(Jan. 1, 2000 through Dec. 31, 2002)

N = 41,898 visits for 31,024 children

Linked to NC Medicaid enrollment file

↓ Matched based on combinations of child's Id, name & date of birth

Medicaid Claims File

(Jan. 1, 2000 through Dec. 31, 2002)

N = 41,666 visits for 27,960 children

↓ Sample restricted to:

- Practices (N=153) with min. of 10 EF & 10 claims during study period
- Visit dates after practice started providing preventive dental services

Analytic datasets

N = 41,252 EFs for 30,606 children

N = 40,909 claims for 27,607 children

Figure 2. Match on preventive dental visits between patient encounter forms and Medicaid claims

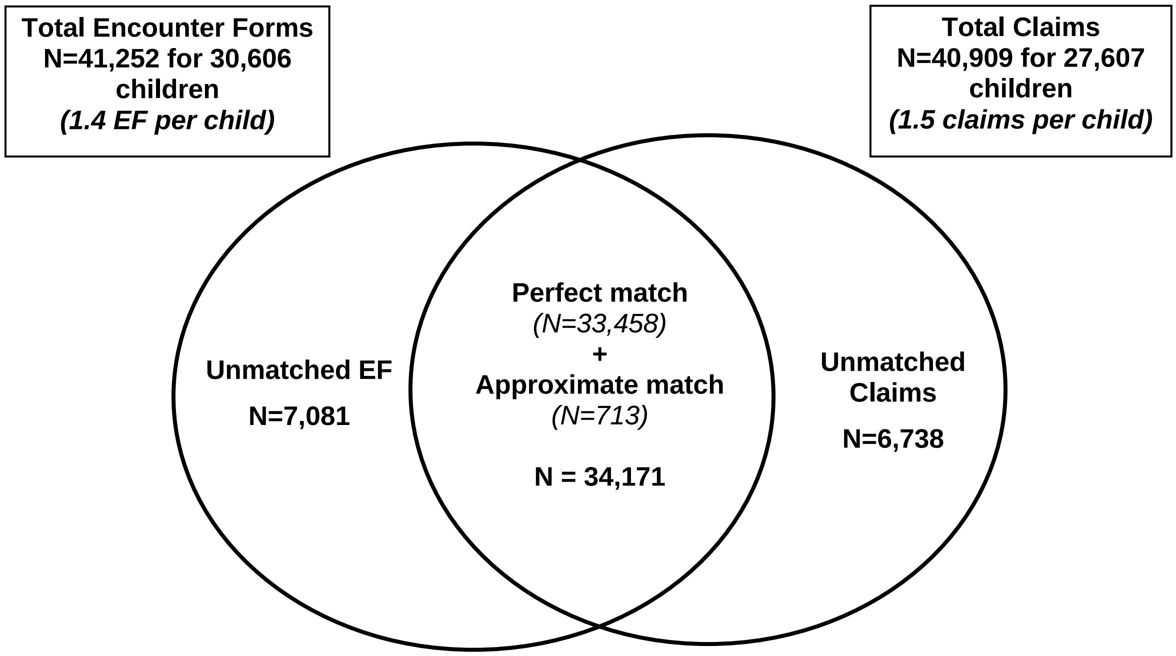

Figure 3. Results of the multinomial logit model for predictors of a match between Medicaid claims and patient encounter forms

	Risk ratios for unmatched claims (C) or unmatched EF (E) vs. a match (M)								
Variables	**.8**	**1.0**	**1.4**	**1.8**	**2.2**	**2.6**	**3.0**	**3.4**	**3.8**
Age at IMB visit (6-35 months)	C E	**M**							
Child is Asian vs. White		**M** C	E						
Child is Black vs. White		**M** C E							
Child is Hispanic vs. White		**M C**	E						
Child is of Other race vs. White		**M**	C E						
Child & provider county are same	E	**M**C							
Family practice vs. Pediatrics		**M**			E				
Urban population of 20,000 or more, adjacent to a metropolitan area	E	**M**							
Variables	**1.0**	**5.0**	**10.0**	**15.0**	**20.0**	**25.0**	**30.0**	**35.0**	**40.0**
First quarter when practice started providing preventive dental services (vs. Fourth quarter, 2002)									
First quarter, 2000	**M** E							C	
Second quarter, 2000	E **M**							C	
Third quarter, 2000	**M** E		C						
Fourth quarter, 2000	**M** E								C
First quarter, 2001	E **M**			C					
Second quarter, 2001	**M** E		C						
Third quarter, 2001	**M** E		C						
Fourth quarter, 2001	**M** E	C							
First quarter, 2002	**M** E	C							
Second quarter, 2002	**M** E	C							
Third quarter, 2002	E **M**	C							

The letters C, E, M correspond to the 3 outcome categories: unmatched Claims (C), unmatched EF (E) and Match (M).
The 'M's are stacked on top of one another because M is the base category.
Only variables significant at $P \le .05$ for at least one comparison are presented.
The lack of statistical significant is depicted by a 'box', indicating that the outcomes are tied together.

Table 1. Results of the multinomial logit model for predictors of a match between EF and claims

Unmatched EF (vs. Match)	Relative Risk Ratio	95% Confidence Interval		z	P>z
Age in months	.99*	.98	.99	–2.44	.015
Male (vs. Female)	.99	.95	1.04	–.29	.772
Child's Race (vs. White)					
Asian	1.69***	1.30	2.18	3.98	.000
Black	1.16**	1.04	1.29	2.69	.007
Hispanic	1.39***	1.19	1.61	4.40	.000
American Indian	.96	.67	1.36	–.24	.810
Other	1.29**	1.09	1.54	3.08	.002
Child's residence county and provider county are the same	.84**	.75	.91	–4.00	.000
Type of practice (vs. Pediatric practice)					
Health department	1.31	.86	2.01	1.24	.215
Family physician practice	2.28***	1.59	3.26	4.50	.000
Low or medium intensity of participation (vs. High)	.97	.74	1.26	–.26	.793
Rural–Urban classification of provider county (vs. Central or fringe counties of metropolitan areas of 1 million pop or more					
Counties in metropolitan areas of 250,000 to 1,000,000 population	.77	.46	1.27	–1.04	.298
Counties in metropolitan areas of less than 250,000 pop	.74	.43	1.27	–1.09	.277
Urban population of 20,000 or more, adjacent to a metropolitan area	.44**	.25	.80	–2.68	.007
Urban pop of 20,000 or more, not adjacent to a metropolitan area	.78	.46	1.33	–.92	.359
Rural or urban pop of 2,500 to19,999, adjacent to a metropolitan area	.64	.41	1.01	–1.93	.053
Rural or urban pop of 2,500 to19,999, not adjacent to a metropolitan area	.69	.46	1.03	–1.84	.066

N = 47,990
Match is the base outcome
* *Significant at* $P \leq .05$, ** *Significant at* $P \leq .001$, *** *Significant at* $P \leq .0001$

Table 1. Results of the multinomial logit model for predictors of a match between EF and claims, contd.

Unmatched EF (vs. Match)	Relative Risk Ratio	95% Confidence Interval		z	P>z
Quarter in which practice first started providing preventive dental services (vs. Fourth quarter, 2002)					
First quarter, 2000	1.24	.60	2.55	.58	.564
Second quarter, 2000	.99	.47	2.09	–.01	.988
Third quarter, 2000	1.62	.86	3.05	1.50	.133
Fourth quarter, 2000	1.55	.63	3.82	.96	.338
First quarter, 2001	.86	.46	1.59	–.49	.623
Second quarter, 2001	1.31	.70	2.44	.85	.393
Third quarter, 2001	1.52	.86	2.72	1.43	.153
Fourth quarter, 2001	1.10	.59	2.07	.30	.765
First quarter, 2002	1.51	.76	2.97	1.18	.236
Second quarter, 2002	1.22	.58	2.55	.53	.598
Third quarter, 2002	.75	.29	1.91	–.61	.545
Unmatched Claims (vs. Match)	**Relative Risk Ratio**	**95% Confidence Interval**		**z**	**P>z**
Age in months	.97***	.96	.99	–4.12	.000
Male (vs. Female)	.99	.95	1.04	–.29	.770
Child's Race (vs. White)					
Asian	.87	.60	1.27	–.71	.479
Black	1.07	.96	1.18	1.22	.221
Hispanic	1.04	.81	1.34	.32	.752
American Indian	.85	.65	1.12	–1.14	.253
Other	1.28**	1.10	1.47	3.29	.001
Child's residence county and provider county are the same	1.00	.89	1.13	.06	.953
Type of practice (vs. Pediatric practice)					
Health department	1.05	.66	1.67	.22	.830
Family physician practice	1.63*	1.02	2.61	2.04	.041
Low or medium intensity of participation (vs. High)	.98	.61	1.55	–.11	.915

N = 47,990
Match is the base outcome
** Significant at $P \le .05$, ** Significant at $P \le .001$, *** Significant at $P \le .0001$*

Table 1. Results of the multinomial logit model for predictors of a match between EF and claims, contd.

Unmatched Claims (vs. Match)	Relative Risk Ratio	95% Confidence Interval		z	P>z
Rural–Urban classification of provider county (vs. Central or fringe counties of metropolitan areas of 1 million pop or more)					
Counties in metropolitan areas of 250,000 to 1,000,000 population	1.23	.73	2.09	.78	.435
Counties in metropolitan areas of less than 250,000 population	1.07	.59	1.92	.22	.828
Urban population of 20,000 or more, adjacent to a metropolitan area	1.56	.79	3.05	1.29	.199
Urban pop of 20,000 or more, not adjacent to a metropolitan area	2.17***	1.44	3.28	3.69	.000
Rural–Urban classification of provider county (vs. Central or fringe counties of metropolitan areas of 1 million pop or more)					
Rural or urban pop of 2,500 to19,999, adjacent to a metropolitan area	1.49	.68	3.25	.99	.321
Rural or urban pop of 2,500 to19,999, not adjacent to a metropolitan area	1.27	.66	2.42	.72	.472
First month in which practice started providing preventive dental services					
First quarter, 2000	36.14***	6.63	197.07	4.15	.000
Second quarter, 2000	35.32***	4.87	256.04	3.53	.000
Third quarter, 2000	12.68**	2.10	76.46	2.77	.006
Fourth quarter, 2000	42.49***	7.51	24.39	4.24	.000
First quarter, 2001	19.25**	3.25	114.00	3.26	.001
Second quarter, 2001	11.51**	2.16	61.45	2.86	.004
Third quarter, 2001	12.36**	2.24	68.19	2.88	.004
Fourth quarter, 2001	9.99**	1.83	54.43	2.66	.008
First quarter, 2002	5.49	.86	35.34	1.80	.072
Second quarter, 2002	6.45*	1.18	35.24	2.15	.031
Third quarter, 2002	2.46	.34	17.92	.89	.376

N = 47,990
Match is the base outcome
* *Significant at $P \leq .05$,* ** *Significant at $P \leq .001$,* *** *Significant at $P \leq .0001$*

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