Accuracy of Pediatric Primary Care Providers' Screening and Referral for Early Childhood Caries

Kate M. Pierce, DDS*‡; R. Gary Rozier, DDS, MPH‡; and William F. Vann, Jr, DMD, PhD*

ABSTRACT. *Purpose.* **Tooth decay is one of the more common diseases of childhood. Slightly >40% of US children are already affected by the time they reach kindergarten. Primary care physicians can play an important role in prevention and control of this disease because of their ready access to this population. Unlike dentists, they see a large percentage of children during their infant and toddler years. However, few studies have been conducted on oral screenings and referrals by primary care physicians or the effectiveness of their oral health preventive activities. The purpose of this study was to determine the accuracy of pediatric primary care providers' screening and referral for Early Childhood Caries.**

Methods. **We sought to compare independent, blinded oral screening results and referral recommendations made by primary care providers with those of a pediatric dentist, considered for purposes of the study to be the reference gold standard. The study was conducted at a private pediatric group practice in North Carolina. The practice was selected because it serves a large volume of Medicaid patients and includes a large number of pediatric primary care providers (11 pediatricians and 1 nurse practitioner). Study participants included Medicaid-eligible children younger than 36 months of age with erupted teeth. The pediatric primary care providers in this practice received 2 hours of training in infant oral health. The training consisted of a review of the study methods and clinical slides illustrating dental caries in various stages of progression. Specific instructions were given to the providers on how to recognize a cavitated carious lesion and how to determine when a dental referral is needed. Providers were instructed to refer any child with 1 or more cavitated carious lesions, soft tissue pathology, or evidence of trauma to the teeth or mouth. Before commencing the study, calibration and a comparative analysis were performed to establish reliability and validity of the examinations performed by the pediatric dentist. Both a pediatric dentist and a pediatric primary care provider conducted a dental screening on each child and recorded carious teeth and whether a dental referral was needed. Sensitivity and specificity were calculated to compare the pediatric primary care providers' screenings to the gold standard (pediatric dentist) in 3 categories: caries at the tooth level, caries at the patient level (1 or more affected teeth), and need for referral.**

Results. **The final study sample consisted of 258 preschool-aged children (122 males and 136 females) with a mean age of 21.2 months (standard deviation [SD]: 9.13). One hundred eighty-four (71.3%) of the participants were white, 58 (22.5%) were black, and 16 (6.2%) were Hispanic.**

Tooth-Level Analysis: **The pediatric dentist reported an average of 0.30 (SD: 0.005) cavitated teeth per child, whereas the pediatric primary care providers reported a mean of 0.25 (SD: 0.004). This difference was not statistically significant (*t* test). The pediatric dentist identified 80 (2.4%) teeth with cavitated carious lesions, whereas the pediatric primary care providers identified 64 (1.9%), 25 of which were false-positives. Their screening results include 41 false-negative teeth. Thus, the primary care providers tended to under-count the number of teeth with carious lesions. They achieved a sensitivity of 0.49 (95% confidence interval [CI]: 0.47–0.51) and a specificity of 0.99 (95% CI: 0.99–1.0) when their screening results for individual teeth were compared with the gold standard.**

Patient-Level Analysis: **At the patient level, the pediatric dentist identified 25 (9.7%) children with 1 or more teeth affected by cavitated lesions. The pediatric primary care providers collectively identified 30 (11.6%) children who had cavitated lesions. They achieved a sensitivity of 0.76 (95% CI: 0.71–0.81) and a specificity of 0.95 (95% CI: 0.93–0.98) in identifying those children with cavitated carious lesions. There were 6 false-negatives and 11 false-positives when the pediatric primary care providers' findings were compared with the gold standard. At the patient-level, the positive predictive value of the dental screening was 0.63 and the negative predictive value was 0.97.**

Dental Referral: **The pediatric dentist referred a total of 27 (10.5%) children to a dentist. Two of these children were referred for trauma and the other 25 were referred for cavities. The pediatric primary care providers referred a total of 23 (8.9%) children to a dentist. Two referrals were made because the provider was concerned about stains on the teeth, whereas the remaining 21 were referred for cavities. The pediatric primary care providers achieved a sensitivity of 0.63 (95% CI: 0.57–0.69) and a specificity of 0.98 (95% CI: 0.96–0.99) when their recommendations for referral were compared with the gold standard. The number of children receiving a referral from a pediatric primary care provider for cavities (*N* = 21) was less than the number of children they identified as having cavities (*N* = 30). The providers as a whole tended to under-refer, and only 70% of children with evidence of dental disease received a referral.**

Conclusions. **After 2 hours of training in infant oral health, the pediatric primary care providers in this study achieved an adequate level of accuracy in identifying children with cavitated carious lesions. Additional training and research would be needed to optimize pediatric primary care providers' identification of carious teeth if that were the goal of screening. However, the purpose of screening by nondental personnel generally is to accurately identify those in need of referral, which does not require a tooth-by-tooth identification of cavities. Addi-**

From the Departments of *Pediatric Dentistry and ‡Health Policy and Administration, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Received for publication Jul 16, 2001; accepted Feb 4, 2002.

Reprint requests to (W.F.V.) CB #7450, Brauer Hall, Chapel Hill, NC 27599-7450. E-mail: bill_vann@dentistry.unc.edu

tional research is also needed to determine how to improve dental referrals by pediatric primary care providers. Results of our study suggest that dental screenings can easily be incorporated into a busy pediatrics practice and that pediatric primary care providers can significantly contribute to the overall oral health of young children by the identification of those children who need to be seen by a dentist. *Pediatrics* 2002;109(5). URL: http://www.pediatrics.org/cgi/content/full/109/5/e82; *physicians, pediatricians, oral health, dental screening/referral, early childhood caries, validity of screening, reliability of screening.*

ABBREVIATIONS. AAP, American Academy of Pediatrics, AAPD, American Academy of Pediatric Dentistry; NC, North Carolina; CI, confidence interval; Sn, sensitivity; Sp, specificity; SD, standard deviation.

Tooth decay is one of the most common diseases of childhood.[1] According to the most recent survey (1988–1994), 8.4% of 2-year-old children in the United States had a least 1 decayed or filled tooth, and by age 5, 40.4% were affected.[2] This survey also revealed that caries in primary teeth varies by poverty status—the lowest income groups have 2 to 5 times more caries than high-income groups.[3] Both the medical and dental professions promote the importance of physicians' involvement in oral health promotion and the prevention of early childhood caries,[4–6] defined as any sign of dental caries on any tooth surface during the first 3 years of life.[2] Despite interest in physicians playing an active role in children's oral health, there are few well-developed practice guidelines for physicians to follow when performing dental screenings or other activities related to infant oral health. An extensive literature search revealed no published studies on oral health guidelines for physicians. In addition, a recent national survey found that many pediatricians lack the current scientific knowledge needed to promote children's oral health.[7]

The Maternal and Child Health Bureau and Health Resources and Services Administration developed a guide, *Bright Futures in Practice: Oral Health,* to address the oral health needs of children and families.[8] This guide recommends that primary care physicians provide regular dental screenings, oral health risk assessments, oral health education, and dental referrals when needed. The American Academy of Pediatrics' (AAP) *Recommendations for Preventive Pediatric Health Care* also suggests that pediatricians should perform dental screenings.[9] Unfortunately, neither publication specifies screening methods, armamentaria needed, conditions that necessitate a dental referral, or how to document oral findings in the patient's medical record. The AAP guidelines indicate that in the absence of dental problems occurring at an earlier age, pediatricians should refer children for their first dental visit at age 3 years.

Very little is known about the ability of physicians to perform an accurate dental screening and make an appropriate referral to a dentist. Only 1 published study has compared dental screenings performed by a pediatrician with those performed by a pediatric dentist.[10] After 4 hours of training, the single study pediatrician achieved a sensitivity of 1.0 and a specificity of 0.87 in detecting nursing caries as compared with a pediatric dentist.[10]

A POTENTIAL SOLUTION TO IMPROVE ACCESS

The American Academy of Pediatric Dentistry (AAPD) and the American Dental Association recommend that children have their first dental visit around 1 year of age.[11,12] Despite this recommendation, many low-income children in North Carolina (NC) and elsewhere are unable to obtain care. The barriers to dental care faced in NC include a shortage of dentists and an even greater shortage of dentists who will treat Medicaid patients.[13] North Carolina Medicaid data from 1998 reveal that 213 089 children between 1 and 5 years of age were eligible for Medicaid.[14] Only 12.2% of these children (N = 25 997) received dental services in 1998,[13] whereas 67.5% (N = 143 835) received medical services.[15] Considering this dramatic difference, it might be advantageous from a public health perspective to incorporate aspects of oral health into regular medical visits. Recent public health literature encourages the integration of medicine and dentistry[16] and advocates providing oral health activities in convenient locations that are easily accessible to a large number of people.[17]

MEDICAID'S PREVENTIVE DENTAL PROGRAM IN NORTH CAROLINA

Recently, the NC Medicaid Program developed and implemented a statewide program in which physicians provide preventive dentistry services. The title of the program is "Into the Mouths of Babes," and its goals are to prevent Early Childhood Caries, educate parents about oral health, identify children with dental caries at an early age, and refer those with dental treatment needs to a dentist. Medicaid reimburses participating physicians for providing a 3-part service (dental screening, oral health education, and fluoride varnish application) to Medicaid-eligible children younger than 36 months with erupted teeth. The criteria for the dental screening require physicians to use a well-directed light source, gauze to dry the teeth, and a disposable dental mirror. They are instructed to record missing teeth and evidence of caries on an examination form that is kept in the patient's chart. Physicians are also asked to record information about the caries risk of each child and counsel the parents about their child's oral health. Finally, the physicians are required to apply fluoride varnish to the child's teeth.

SPECIFIC AIMS

Questions remain about the appropriate role of physicians in oral health. The AAP and the AAPD disagree on the appropriate age of a child's first dental visit, and the evidence on how well physicians perform dental screenings is not clear. Accordingly, the emergence of this new statewide program in NC offered the opportunity to address several relevant questions about the role of physicians in oral health. The specific aims of this study were to assess the

accuracy of pediatric primary care providers' dental screenings and to assess their ability to determine those children who need a dental referral.

METHODS

Patient Enrollment and Data Collection

This study was conducted at a private pediatric group practice in NC between July 24, 2000, and September 1, 2000. The practice site was selected because it served a large volume of Medicaid-eligible patients, included a large number of pediatric primary care providers (11 pediatricians and 1 nurse practitioner), and it was a pilot site for the "Into the Mouths of Babes" program. Study participants included consecutive children <36 months of age with erupted teeth who were participating in the "Into the Mouths of Babes" program. Informed consent was obtained from each parent according to the ethical guidelines outlined by the institutional review board at the University of North Carolina–Chapel Hill School of Dentistry. Patients were excluded from the study if they had received the fluoride varnish and oral screening within 3 months, if they were very ill, or if the parents declined participation. As compensation for participation, children received a toothbrush and toothpaste and parents received oral health anticipatory guidance for their children.

Before implementing the "Into the Mouths of Babes" program in their practices, physicians were required to attend a 1-hour training session that included an orientation to all aspects of the Medicaid program (dental screenings, oral health education, and fluoride varnish application). The pediatric primary care providers at the study practice were given an additional hour of in-office training in dental screening and infant oral health. This training consisted of a review of the study methods and clinical slides illustrating caries in various stages of progression. Specific instructions were given to the providers on how to recognize a carious lesion, which was defined as a cavitation with a definite break in the enamel surface. The providers were taught how to determine whether a dental referral is appropriate and were instructed to refer any child with 1 or more cavitated carious lesions, soft tissue pathology, or evidence of trauma to the teeth or mouth. The providers were given an opportunity to ask questions as well as discuss their impressions of cases presented in the slides.

After consent was obtained, each child received 2 dental screenings, 1 performed by 1 of the pediatric primary care providers and another performed by the pediatric dentist. Both examinations were performed in the same manner but were conducted in separate rooms. The pediatric primary care providers and the pediatric dentist were blinded to the other's findings and were not allowed to discuss a particular case until the findings had been documented and the child had been dismissed from the clinic.

The screenings were conducted in the knee-to-knee position or with the child lying on the examination table. As specified by the World Health Organization guidelines, the providers used a well-directed light source and reflected light with a disposable dental mirror.[18] The providers used light finger pressure to open the child's mouth, dried the teeth with gauze, and examined all teeth in a systematic fashion.

The pediatric primary care providers recorded missing teeth (unerupted or extracted) and teeth with cavitated carious lesions on the screening forms provided by Medicaid. They also recorded whether the child had any soft tissue pathology and whether they needed a dental referral. Finally, the providers recorded information about the oral health behaviors and caries risk of each child. The information from their examination forms was transferred into numeric codes for easier computer entry.

The pediatric dentist recorded findings on a slightly modified version of the Medicaid form. She recorded a code for each of the primary teeth to indicate whether it was healthy or diseased. Like the pediatric primary care providers, the pediatric dentist recorded soft tissue pathology and whether the child needed a dental referral.

The pediatric dentist also recorded whether the child had 1 or more precavitated (incipient) carious lesions. A smooth surface precavitated lesion was defined as a white, chalky, opaque area with loss of luster on an intact enamel surface.[19,20] A pit or fissure precavitated lesion was defined as a lesion with significant staining, discoloration, or rough spots in the enamel without a visible break in the enamel surface.[20] This definition included pits and fissures that were light or dark brown at the base with a chalky, white demineralization along the sides.[21]

Recent literature emphasizes the importance of diagnosing caries in the early precavitated stage rather than waiting for the occurrence of cavitation.[22] Pilot work for the present study revealed an unacceptable level of reliability for diagnosing precavitated lesions at the tooth level; accordingly, the pediatric primary care providers were not asked to identify precavitated lesions. Because the pediatric dentist achieved an acceptable level of reliability in identifying precavitated lesions at the patient level, she collected this information.

Intra-examiner Reliability and Validity

Before commencing the study, calibration and a comparative analysis were performed to establish reliability and validity of the examinations performed by the pediatric dentist. Results of the reliability study found that the pediatric dentist had acceptable agreement for cavitated lesions at the tooth level (κ = 0.99; 95% confidence interval [CI]: 0.85–0.97), cavitated lesions at the patient level (κ = 0.90; 95% CI: 0.72–1.09), precavitated lesions at the patient level (κ = 0.68; 95% CI: 0.42–0.94), and need for referral (κ = 0.90; 95% CI: 0.72–1.09). Validity, established using an experienced pediatric faculty member as the gold standard, was also acceptable for cavitated lesions at the tooth level (sensitivity [Sn] = 0.77, 95% CI: 0.74–0.80; specificity [Sp] = 0.99, 95% CI: 0.99–1.0), cavitated lesions at the patient level (Sn = 0.89, 95% CI: 0.79–0.99; Sp = 1.0), precavitated lesions at the patient level (Sn = 0.79, 95% CI: 0.66–0.92; Sp = .80, 95% CI = 0.68–0.93), and need for referral (Sn = 0.89, 95% CI = 0.79–0.99; Sp = 1.0).

Data Analysis

Data were analyzed using SAS for Windows Version 8.10 (SAS Institute, Cary, NC). Descriptive analysis included calculations of the number of participants examined, the number of teeth examined, mean age, sample distribution by race, the number of children with caries, and the mean number of carious lesions per child. In addition, a descriptive analysis was performed to compare the number of teeth with cavitated lesions and the number of children with cavitated lesions found by each provider compared with the pediatric dentist.

Sensitivities, specificities, positive predictive values, and negative predictive values were calculated to compare the findings of the pediatric primary care providers (pediatricians and nurse practitioner) with the gold standard (pediatric dentist) in the following areas: 1) cavitated carious lesions at the tooth level, 2) cavitated carious lesions at the patient level, and 3) whether a dental referral was needed. The sensitivities and specificities for the pediatricians and the nurse practitioner were compared using a test of difference between 2 proportions.[23] The level of significance was set at α = 0.05.

As 1 dimension of the tooth-level analysis, the mean number of affected teeth per child and its standard deviation (SD) were calculated from the pediatric dentist's findings and from the pediatric primary care providers' findings. A t test was used to determine whether the 2 means differed by chance, with the level of significance set at α = 0.05.

RESULTS

Characteristics of the Study Sample

The final study sample consisted of 258 preschool-aged children (122 males and 136 females) with a mean age of 21.2 months (SD: 9.13). One hundred eighty-four (71.3%) of the participants were white, 58 (22.5%) were black, and 16 (6.2%) were Hispanic.

None of the children had received any previous restorative dental care or extractions. In total, 3315 teeth were examined (mean = 12.8 teeth/child). The pediatric dentist identified 80 teeth (2.4%) with cavitated carious lesions, a mean number of 0.3 per child. Of those children with 1 or more cavitated lesions, the mean number of affected teeth per child was 3.2.

The pediatric dentist found 25 (9.7%) children with

1 or more cavitated carious lesions, but the disease rate was much higher when precavitated lesions were included (Table 1). Twenty-three (8.9%) children had both precavitated and cavitated lesions, and 47 (18.2%) had precavitated lesions only. Thus, a total of 70 (27.1%) children had 1 or more precavitated lesions. Only 2 (0.8%) children had cavitated lesions but no precavitated lesions.

Provider-Level Analysis

Eleven pediatricians and 1 nurse practitioner participated in this study. Table 2 displays the number of teeth and children with cavitated lesions identified by each medical provider compared with the dentist. The pediatric primary care providers tended to underdiagnose the number of teeth with cavitated lesions and to overdiagnose the number of children who had 1 or more cavitated lesions. However, 7 (58%) of the 12 pediatric primary care providers were in perfect agreement with the pediatric dentist relative to the number of children who had 1 or more cavitated lesions, and the remaining providers differed by only 1 or 2 children. The nurse practitioner performed dental screenings and referrals with comparable sensitivity and specificity to the pediatricians; therefore, her results have been combined with that of the pediatricians in subsequent presentations.

Tooth-Level Analysis

The pediatric dentist reported an average of 0.30 (SD: 0.005) cavitated teeth per child, whereas the pediatric primary care providers reported a mean of 0.25 (SD: 0.004). This difference was not statistically significant (t test; $P = .14$). The pediatric dentist identified 80 (2.4%) teeth with cavitated carious lesions, whereas the pediatric primary care providers identified 64 (1.9%), including 25 false-positives. They also identified 41 false-negative teeth. The pediatric primary care providers achieved a sensitivity of 0.49 (95% CI: 0.47–0.51) and a specificity of 0.99 (95% CI: 0.99–1.0) when their screening results for individual teeth were compared with the gold standard.

Patient-Level Analysis

Compared with the gold standard, the primary care providers correctly classified 93% of children as having or not having 1 or more cavitated lesions. The pediatric dentist identified 25 (9.7%) children with cavitated lesions. The pediatric primary care providers collectively identified 30 (11.6%) children who had cavitated lesions, including 11 false-positives. Six (54.6%) of the 11 children incorrectly identified as having some teeth with cavitated lesions were found by the pediatric dentist to have some precavitated lesions. In addition, the providers incorrectly identified 6 children as being caries-free. They achieved a sensitivity of 0.76 (95% CI: 0.71–0.81) and a specificity of 0.95 (95% CI: 0.93–0.98) in identifying those children with cavitated carious lesions. The positive predictive value of the dental screening at the patient level was 0.63, and the negative predictive value was 0.97.

Dental Referral

Table 3 displays the number of children who received a dental referral according to their disease status. The pediatric dentist referred a total of 27 (10.5%) children to a dentist. Two of these children were referred for trauma and the other 25 for cavities. The pediatric primary care providers referred a total of 23 (8.9%) children to a dentist (Sn = 0.63, 95% CI = 0.57–0.69; Sp = 0.98, 95% CI = 0.96–0.99). Two referrals were made because the provider was concerned about stains on the teeth, and the remaining 21 were referred for cavities.

The number of children receiving a referral from a pediatric primary care provider for cavities ($N = 21$) was less than the number of children they identified as having cavities ($N = 30$). As a group they tended to under-refer and only 70% of children with evidence of dental disease received a referral.

DISCUSSION

Study Limitations

One weakness of our study is that bias may have occurred because the pediatric primary care providers knew they were participating in the study. They may have performed better than they would have otherwise because they knew they were being evaluated.

A second weakness is that the results of this study might not apply to other physicians in NC or elsewhere. The providers at the study practice had the advantage of an extra training session over others participating in the statewide oral health program. They also had the advantage of receiving consultation from the pediatric dentist who was available for 6 weeks in their practice to answer questions about oral health. The providers continuously asked questions and had their impressions validated; thus, their ability to detect caries likely improved as the study progressed.

Possible inadequacies in the training sessions are another limitation of this study. Neither the training session used in the "Into the Mouths of Babes" program nor the extra training session used in this study

TABLE 1. Number of Children With Cavitated and Precavitated Lesions by Age

Age (Months)	Number of Children With Cavitated Lesions Only (%)	Number of Children With Precavitated Lesions Only (%)	Number of Children With Cavitated and Precavitated Lesions (%)	n
<12	0 (0)	4 (5.9)	1 (1.5)	67
12–23	1 (1.2)	18 (20.9)	2 (2.3)	86
24–35	1 (0.9)	25 (23.8)	20 (19.0)	105
All	2 (0.8)	47 (18.2)	23 (8.9)	258

TABLE 2. Number of Teeth and Children With Cavities Found by Pediatric Primary Care Provider Compared With the Dentist

PPCP	Number of Patients Examined	Number of Teeth With Cavities		Number of Children With Cavities	
		PPCP	DDS	PPCP	DDS
1	10	1	1	1	1
2	22	7	11	4	4
3	26	8	11	3	4
4	15	4	2	3	2
5	19	8	10	3	2
6	29	4	7	2	2
7	20	1	4	1	1
8	36	18	16	6	4
9	14	2	2	1	1
10	5	0	0	0	0
11	19	2	2	1	1
12*	43	9	14	5	3
Totals	258	64	80	30	25

PPCP indicates pediatric primary care provider; DDS, dentist.
* Nurse practitioner.

TABLE 3. Number of Children Receiving a Dental Referral by Disease State and Provider Type

Disease State	Pediatric Dentist			Pediatric Primary Care Providers		
	Number of Children	Referral	No Referral	Number of Children	Referral	No Referral
Precavitated lesions only	47	0	47	NA	NA	NA
Cavitated lesions only	2	2	0	30	21	9
Cavitated and precavitated lesions	23	23	0	NA	NA	NA
Healthy dentition	186	2	184	228	2	226
Total	258	27	231	258	23	235

NA indicates not applicable.

have been evaluated in a controlled study. The physicians may have performed better had a different training format been implemented. The purpose of this study was not to determine whether 2 hours of training in infant oral health was sufficient, but whether physicians can accurately perform dental screenings after training similar to but not identical to the limited training provided in the statewide program. The providers performed quite well with the limited training they received, and we speculate that the accuracy of their screenings would improve if they were given more training.

One final limitation is the lack of follow-up with the providers who participated in this study. Valuable information could have been obtained from follow-up conversations with the providers to determine the reasons why referrals were not provided for all children with evidence of dental disease.

Accuracy of Primary Care Providers' Dental Screenings

The pediatric primary care providers had the most difficulty identifying caries on individual teeth. The low sensitivity achieved at the tooth level is not of concern because the goal of the "Into the Mouths of Babes" program is to identify children who exhibit dental disease and thus need to be referred to a dentist. The oral examination is intended as a screening tool only and not a comprehensive dental examination. It is not important whether the pediatric primary care provider accurately identifies and records cavities on each tooth because the dentist will do so when the child presents for a comprehensive dental examination. These dental screenings are performed solely for the purpose of identifying children who need a dental referral.

Considering the serious health and financial consequences of untreated dental disease, it is important for pediatric primary care providers to accurately identify children with dental disease and provide them with an appropriate dental referral. The providers achieved the best accuracy at the patient level, with a sensitivity of 76%, a specificity of 95%, and an overall accuracy of 93%. False-negatives can be of concern because these children with disease may not receive needed dental care. In our study, about 1 of every 4 children with carious lesions fell into this category. False-positives, on the other hand, will not suffer any harm from the inaccurate classification. They will simply receive a dental referral, which is recommended by the AAPD for all children by 1 year of age. The sensitivities and specificities for the dental screenings in this study were at least as high as those of other accepted physical screenings done by primary care physicians such as screenings for hearing and vision.[24,25]

Implications of Findings

Another important question that can be addressed by this study is the probability of dental caries in those children who are screened by pediatric primary care providers. The probability in those with either a positive or negative screening result, known as the positive and negative predictive values respectively, is affected by the prevalence of disease in the

screened population.[26] The predictive value of a test is higher when the prevalence of disease is higher; therefore, it is advantageous to use screening tests on high-risk populations.[26] This Medicaid population should be at greater risk for dental caries than non-Medicaid children. Nevertheless, only 9.7% of children in our study had evidence of cavitated carious lesions. This low prevalence may have decreased the positive predictive value of the providers' dental screenings.

The pediatric dentist noted that 6 (54.6%) of the 11 children who were false-positives actually had precavitated lesions indicating dental caries in the early stages. Using the diagnostic threshold for cavitated lesions in this study, the pediatric primary care providers tended to overdiagnose caries at the patient level; however, there would have been only 5 false-positives if precavitated lesions had been included. If these 5 participants were moved to the true-positive category, the positive predictive value would be 0.83 instead of 0.63. Thus, the positive predictive value of the pediatric primary care providers' dental screenings is higher than it appears because 54.6% of the false-positives had early stages of disease and technically can be considered true-positives.

Measurement Issues

Questions remain about the appropriate diagnostic criteria for pediatric primary care providers to rely on when screening for caries. The dental literature emphasizes the importance of including precavitated lesions in the diagnostic criteria when performing caries examinations[2,22]; however, reliability is often unacceptable.[22] Pediatric primary care providers were not asked to identify precavitated lesions because pilot work for the present study revealed an unacceptable level of reliability for the gold standard at the tooth level. Because the dentist in this study achieved an acceptable level of reliability and validity for precavitated lesions at the patient level, she included their measurement in her examinations. She found that 47 (18.2%) children had precavitated lesions only and were therefore not referred to a dentist using the case definition developed for this study. Unfortunately, identification of precavitated carious lesions is not accurate enough at the present time. Until better validity and reliability can be achieved, pediatric primary care providers must adhere to the standard of caries diagnosis used in this study, which includes cavitated lesions only.

Disconnect Between Identifying Caries and Recommending a Dental Referral

The pediatric primary care providers were instructed in the training sessions to make a dental referral for any child with 1 or more cavitated carious lesions. Our results suggest that pediatric primary care providers do better in the identification of disease than they do in referring. They identified 30 children with caries but referred only 21 (70%) of them. At the training sessions they were urged to refer in any circumstance where there was doubt. We thought this guidance would lead to over-referral, but the opposite phenomenon was found. The fact that 54.5% (6 of 11) of the false-positives at the patient-level actually had early stages of disease supports the need to refer if there is any doubt about whether a child has caries.

The reasons for this identification/referral disconnect are unknown. We speculate that the pediatric primary care providers may not have referred because they did not have a dental provider to whom they could refer. NC's severe shortage of dentists and inadequate number of Medicaid providers leaves many young, low-income children without access to dental care. In addition, the pediatric primary care providers may not have referred because they did not want to burden the parent or because they did not think the disease was sufficiently advanced to warrant a referral. Finally, they may have failed to refer because they lacked confidence in their abilities to recognize a carious lesion. Additional research is needed to better understand reasons for differences between identifying disease and providing a referral. At the same time, we point out again that there are no guidelines in the literature for pediatric primary care providers to follow when referring children to a dentist.

CONCLUSION

1. After 2 hours of training in infant oral health, the pediatric primary care providers in this study achieved an adequate level of accuracy in identifying children with 1 or more cavitated carious teeth.
2. The pediatric primary care providers referred only 70% of the children they identified with evidence of dental disease. More research is needed to understand why they do not refer all children who they identify with disease.
3. Dental screenings can easily be incorporated into a busy primary care pediatrics practice and our results suggest that pediatric primary care providers can significantly contribute to the overall oral health of young children by the early identification of children who need to be seen by a dentist.

ACKNOWLEDGMENTS

This study was supported by the Maternal and Child Health Training grant 6T83-MC-00015–07-01 and a Research Fellowship from the American Academy of Pediatric Dentistry Foundation and Omnii Oral Pharmaceuticals.

We would like to express our appreciation to the physicians and staff at Thomasville Pediatrics, the site where this study was conducted.

REFERENCES

1. US Department of Health and Human Services. *Oral Health in America. A Report of the Surgeon General*. Rockville, MD: US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health; 2000
2. Drury TF, Horowitz AM, Ismail AI, Maertens MP, Rozier RG, Selwitz RH. Diagnosing and reporting early childhood caries for research purposes. A report of a workshop sponsored by NIDCR, HRSA and HCFA. *J Public Health Dent*. 1999;59:192–197
3. Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III 1988–1994. *J Am Dent Assoc*. 1998; 129:1229–1238
4. Herrmann HJ, Roberts MW. Preventive dental care: the role of the pediatrician. *Pediatrics*. 1987;80:107–110

5. Johnsen DC. The role of the pediatrician in identifying and treating dental caries. *Pediatr Clin N Am*. 1991;38:1173–1181
6. Nirschl RF, Kronmiller JE. Evaluating oral health needs in preschool children. *Clin Pediatr*. 1986;25:358–362
7. Lewis CW, Grossman DC, Domoto PK, Deyo RA. The role of the pediatrician in the oral health of children: a national survey. *Pediatrics*. 2000;106(6). Available at: http://www.pediatrics.org/cgi/content/full/106/6/e84
8. Maternal and Child Health Bureau, Health Resources and Services Administration. Bright Futures in Practice: Oral Health 1996. Available at: http://www.bright futures.org. Accessed March 1, 2001
9. American Academy of Pediatrics. *Recommendations for Preventive Pediatric Health Care 2000*. Available at: http://www.aap.org/policy
10. Serwint JR, Mungo R, Negrete VF, Duggan AK, Korsch BM. Child-rearing practices and nursing caries. *Pediatrics*. 1993;92:233–237
11. American Academy of Pediatric Dentistry. Infant oral health guidelines. *Pediatr Dent*. 1997;19:70
12. American Dental Association. *Your Child's Teeth*. Chicago, IL: American Dental Association; 1997
13. North Carolina Institute of Medicine Task Force on Dental Care Access. *Report to the North Carolina General Assembly and to the Secretary of the North Carolina*. Chapel Hill, NC: Department of Health and Human Services; 1999
14. Health Care Financing Administration. 2082 Report for Federal Fiscal Year 1998. Available at: http://www.hcfa.gov/medicaid/msis/2082–98.htm. Accessed December 10, 2001
15. North Carolina Division of Medical Assistance. Statistical report on medical care: eligibles, recipients, payments and services. Sections D (4) and G (1). Raleigh, NC: North Carolina Division of Medical Assistance; 1998
16. Mouradian WE, Wehr E, Crall JJ. Disparities in children's oral health and access to dental care. *JAMA*. 2000;284:2625–2631
17. Weintraub JA. Prevention of Early Childhood Caries: a public health perspective. *Community Dent Oral Epidemiol*. 1998;26(suppl 1):62–66
18. World Health Organization. *Oral Health Surveys: Basic Methods*. 4th ed. Geneva, Switzerland: World Health Organization; 1997
19. Howat AP. A comparison of the sensitivity of caries diagnosis criteria. *Caries Res*. 1981;15:331–337
20. Pitts NB, Fyffe HE. The effect of varying diagnostic thresholds upon clinical caries data for a low prevalence group. *J Dent Res*. 1988;67:592–596
21. Ismail AI, Shoveller J, Langille D, MacInnis WA, McNally M. Should the drinking water of Truro, Nova Scotia be fluoridated? Water fluoridation in the 1990's. *Community Dent Oral Epidemiol*. 1993:21:18–25
22. Ismail AI. Clinical diagnosis of precavitated carious lesions. *Community Dent Oral Epidemiol*. 1997;25:13–23
23. Fleiss JL. *Statistical Methods for Rates and Proportions*. New York, NY: John Wiley and Sons; 1981
24. US Preventive Services Task Force. *Guide to Clinical Preventive Services*. 2nd ed. Alexandria, VA: International Medical Publishing; 1996
25. Hall SM, Pugh AG, Hall DMB. Vision screening in the under-5s. *BMJ*. 1982;285:1096–1098
26. Gordis L. *Epidemiology*. Philadelphia, PA: WB Saunders Co; 1996