Effects of Physician-Based Preventive Oral Health Services on Dental Caries
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abstract

BACKGROUND: Most Medicaid programs reimburse nondental providers for preventive dental services. We estimate the impact of comprehensive preventive oral health services (POHS) on dental caries among kindergarten students, hypothesizing improved oral health among students with medical visits with POHS.

METHODS: We conducted a retrospective study in 29,173 kindergarten students by linking Medicaid claims (1999–2006) with public health surveillance data (2005–2006). Zero-inflated regression models estimated the association between number of visits with POHS and (1) decayed, missing, and filled primary teeth (dmft) and (2) untreated decayed teeth while adjusting for confounding.

RESULTS: Kindergarten students with ≥4 POHS visits averaged an adjusted 1.82 dmft (95% confidence interval: 1.55 to 2.09), which was significantly less than students with 0 visits (2.21 dmft; 95% confidence interval: 2.16 to 2.25). The mean number of untreated decayed teeth was not reduced for students with ≥4 POHS visits compared with those with 0 visits.

CONCLUSIONS: POHS provided by nondental providers in medical settings were associated with a reduction in caries experience in young children but were not associated with improvement in subsequent use of treatment services in dental settings. Efforts to promote oral health in medical settings should continue. Strategies to promote physician-dentist collaborations are needed to improve continuity of care for children receiving dental services in medical settings.

WHAT'S KNOWN ON THIS SUBJECT: The US Preventive Services Task Force recommends primary care clinicians apply fluoride varnish to the teeth of all young children, but no studies have examined the effect of comprehensive preventive oral health services on children's clinical oral health status.

WHAT THIS STUDY ADDS: Comprehensive preventive oral health services delivered by primary care clinicians can help improve the oral health of Medicaid-enrolled children, but more work is needed to link medical and dental offices to ensure the continuity of dental care for these children.
Despite improvements in US children's oral health,\textsuperscript{1,2} reports from
the past decade have revealed large disparities in oral health; poor access
to care for some subgroups, leading
to large amounts of untreated decay;
and a high and increasing prevalence
of caries among preschool-aged
children.\textsuperscript{2} National surveys report
that approximately one-third
of children aged 2 to 5 years
experienced dental caries in
1999–2002\textsuperscript{3}; 1 in 4 children aged 3 to
5 years living in poverty in
2009–2010 had untreated caries, 2.5
times that of other children\textsuperscript{4}; and
only 4.1% of children younger than 4
years had professional fluoride
applications in 2009.\textsuperscript{5}

Because most children have more
physician visits than dentist visits
during the first 3 years of life,
expanding the traditional
involvement of primary care medical
practitioners in oral health promotion
has been proposed to address these
dental problems.\textsuperscript{5–8,9,10} Access to
preventive oral health services
(POHs) would be increased if
provided by physicians and nurses
because they can deliver preventive
services in communities without
a sufficient dental workforce and for
patients unlikely to visit a dentist,
monitor children's oral health,
prioritize referrals, and help facilitate
dental visits for the highest-risk
children until they establish a dental
home.

The US Preventive Services Task
Force (USPSTF) recommends primary
care clinicians apply fluoride varnish
to the teeth of all children aged ≤5
years and state Medicaid programs
incorporating this approach have
become widespread since 1998.\textsuperscript{11,12}
Several states reimburse physicians
through their public insurance
programs for dental screenings and
oral health counseling, and almost all
reimburse physicians for the
application of fluoride varnish.\textsuperscript{12,13}
The literature suggests that
physicians will adopt these services
and provide quality care that is
effective in increasing access to
preventive services, reducing
treatment needs, averting
hospitalizations, and lowering
Medicaid costs.\textsuperscript{14–20} Studies reporting
improved oral health have either
provided circumstantial evidence on
the basis of administrative claims\textsuperscript{18,19}
or have not examined comprehensive
services, which include fluoride
varnish applications.\textsuperscript{15} This study
extends previous work by evaluating
the impact of comprehensive POHS,
which includes screening and risk
assessment, fluoride varnish
applications, and parental oral health
counseling, provided in medical
offices by nondental providers, on the
dental caries experience of children
enrolled in North Carolina's (NC's)
Medicaid program.

METHODS

Study Design

We conducted a retrospective cohort
study using surveillance data and NC
Medicaid files for children enrolled in
Children would have received POHS
from 2000–2003, when NC Medicaid
reimbursed providers for up to 6
visits per child up to 3 years of age.\textsuperscript{21}
Because this time period coincides
with the beginning of
implementation, many children did
not visit participating providers or
receive the recommended number of
visits. We use this population to
examine the association between the
number of medical visits with POHS
and subsequent oral health outcomes.
Children with or without POHS could
also have received dental visits, the
recommended standard of care in
areas with a sufficient dental
workforce.

Sample

Oral health surveillance data were
available from the NC Oral Health
Section for 92 127 kindergarten
children in 98 of 100 NC counties
(82% of the state’s public school
kindergarten enrollment).\textsuperscript{22} These
data are collected annually by public
health dental hygienists who conduct
standardized screenings of all
kindergarten students in public
schools. Screenings provide
information about overall dental
caries experience and the amount of
dental treatment received, and these
surveillance data have shown good
reliability when compared with an
experienced dentist performing
a standard examination.\textsuperscript{22–24} A
strength of this study is the
independent assessment of caries
experience because it is not biased
by knowledge of enrollment in
Medicaid or receipt of POHS.
Medicaid enrollment and claims files
for 2000–2006 were obtained from
the NC Division of Medical Assistance.
These files provide information
about each enrolled child, including
the following: demographic
characteristics, length of enrollment,
and services reimbursed by
Medicaid.

The surveillance data and Medicaid
files were previously linked by using
Link King software (Camelot
Consulting, Olympia, WA), which
uses probabilistic and deterministic
methods to match individual records
on the basis of name, date of birth,
gender, race, and county of
residence.\textsuperscript{25,26} From the
kindergarten surveillance data, 34
743 children were successfully
matched to Medicaid claims of
children enrolled before age 1 year
and were still enrolled after their
first birthday. Children were
excluded from the analysis if they
had a nonunique identification
number (n = 442), had <1 year of
Medicaid enrollment before 3 years
of age (n = 3095), had POHS claims
posteligibility (n = 82), or were
missing oral health surveillance
measures (n = 1951). Our sample
included 29 173 children with
Medicaid claims, which is
comparable to the proportion of
children of this age enrolled in NC
Medicaid.\textsuperscript{27}
Measures
We analyzed caries experience, a measure of a child’s dental health status, using a composite index of the number of decayed, missing, and filled teeth (dmft), derived from a visual inspection of the primary dentition of kindergarten students. Primary incisors were excluded from the count of missing teeth because they could be missing for noncarious reasons, mostly natural exfoliation. We also analyzed the number of untreated decayed teeth (dt), a measure of the extent to which a child’s treatment needs for dental caries are being met. Both measures have a potential range of 0 to 20 primary teeth.

The main explanatory variable indicates the number of medical visits with POHS (0 [reference group], 1, 2, 3, and 4–6) received before a child’s third birthday. Visits with POHS were identified with reimbursement for any combination of Current Dental Terminology codes for screening, counseling, and topical fluoride. Physicians were required to bundle these services to qualify for reimbursement.

The selection of explanatory variables was guided by the behavioral model for health care service use.28 We hypothesized that the receipt of POHS would be influenced by child-level predisposing characteristics (gender, race [white, black, other], Hispanic ethnicity, and special health care needs), enabling characteristics (total months enrolled in Medicaid and well-child visits), and need (previous receipt of caries-related treatment, an indicator of high caries risk).29 In addition, characteristics of the health care system and external environment (POHS received in a health department and county-level measures of rural or urban status30; proportion of population with fluoridated public drinking water; number of dentists, pediatricians, and physicians31; and Medicaid-eligible individuals <18 years per 10 000 population32) were hypothesized to affect POHS.

Propensity Score Estimation
Because children were not randomly assigned to receive POHS, our effect estimates could potentially be biased. If providers target POHS at children with or at high risk of caries, the effect of POHS on dental caries may be underestimated. Conversely, if lower-risk children were more likely to receive POHS, its impact on caries may be overestimated. To address observed confounding, we estimated propensity scores with inverse probability of treatment weights (IPTWs).33,34 The goal of IPTWs was to obtain a group of children who were as similar as possible, differing only in their exposure to POHS.33

Propensity scores were estimated by using logistic regression to predict the likelihood of receiving POHS during a medical visit as compared with not receiving POHS, controlling for the aforementioned covariates, including squared terms of continuous variables and excluding the variable indicating receipt of treatment due to its relationship with the exposure variable. For each child, we calculated standardized weights, an approach that assigns greater weight to children who received POHS, but who have characteristics more similar to children who did not have any POHS and vice versa.34 Groups were more similar after IPTW adjustment, as evidenced by the similar distribution of propensity scores among children with and without POHS (Supplemental Fig 3) and improved covariate balance shown by absolute standardized differences <10% (Supplemental Fig 4).35

Analytical Approach
One-way rank analysis of variance (Kruskal-Wallis test) was used to test for differences in mean dmft and dt between children with 0, 1, 2, 3, and ≥4 visits with POHS. We modeled dmft and dt using zero-inflated negative binomial (ZINB) regression models. For the logit part of the ZINB models, odds ratios indicate the odds of having excess zero dmft or dt, a nonrandom zero in the sense of being considered not at risk of caries. For the negative binomial parts, our response variable is the number of dmft or dt among children considered to be at risk of caries, interpreted as an incident rate ratio. We estimated marginal mean outcomes and 95% confidence intervals (CIs) using 500 bootstrap replications, by averaging the predicted marginal means across all children (ie, combining ZINB regression coefficients from model parts for not-at-risk and at-risk classes of children) fixing the number of visits with POHS at 0, 1, 2, 3, and ≥4, in turn, while allowing other covariates to be adjusted at their observed values.36 In addition, to assess overall effects of POHS, we averaged differences in the predicted outcomes over all children assuming they had 0 visits and their outcome assuming they had 1, 2, 3, and ≥4 visits with POHS, respectively, and assessed these using Wald tests and 95% CIs.37 All tests were performed in Stata/IC 12 (StataCorp, College Station, TX) with the use of a 0.05 significance level. This study was approved by an institutional review board at the University of North Carolina at Chapel Hill.

RESULTS
Unadjusted Analysis
Table 1 indicates that 69.7% of children had 0 visits with POHS (n = 20 322). Among children who received POHS (n = 8851), 51.3% had 1 visit (n = 4540), 29.3% had 2 visits (n = 2596), 13.1% had 3 visits (n = 1160), and 6.3% had ≥4 visits (n = 555). Children with more POHS visits had more well-child visits, on average, before their third birthday and lived in counties with more Medicaid-eligible children and fewer dentists.
Overall, 47.9% of children had >0 dmft and 25.3% had >0 dt by the time they entered kindergarten. Children had an average of 2.19 dmft (SD = 3.19) and 0.76 dt (SD = 1.78). Results of the Kruskal-Wallis test indicated that dmft, but not dt, differed significantly between children with 0, 1, 2, 3, and 4 visits with POHS. The unadjusted mean number of dmft and dt was lowest among children who received ≥4 POHS visits (dmft = 1.76, SD = 2.98; dt = 0.51, SD = 1.34) and highest among children with 0 POHS visits (dmft = 2.23, SD = 3.22; dt = 0.78; SD = 1.82).

**Adjusted Analysis**

Children with ≥4 visits with POHS were predicted to have 0.39 fewer dmft, on average, than those with 0 visits (Table 2). As shown in Fig 1, the adjusted marginal mean number of dmft was predicted to be lower at a statistically significant level among children with ≥4 visits with POHS (1.82; 95% CI: 1.55 to 2.09) than 0 (2.21; 95% CI: 2.16 to 2.25) or 2 (2.03; 95% CI: 1.90 to 2.16) visits, and nearly significantly lower than 1 visit (2.20; 95% CI: 2.08 to 2.32). This outcome reflects results from the second part of the ZINB model in which children at risk of dmft with ≥4 visits had significantly lower mean dmft than did children with 0 visits (incident rate ratio: 0.84; 95% CI: 0.76 to 0.94) (Table 2).

Table 2 presents the results of the ZINB model used to estimate the adjusted number of dt. Although children with 2 visits had significantly fewer predicted dt compared with 0 visits (Table 2), Fig 2 shows that the adjusted marginal mean number of dt was similar for all groups (0 visits = 0.77 [95% CI: 0.72 to 0.83]; 1 visit = 0.77 [95% CI: 0.70 to 0.85]; 2 visits = 0.68 [95% CI: 0.61 to 0.75]; 3 visits = 0.79 [95% CI: 0.66 to 0.91]; ≥4 visits = 0.61 [95% CI: 0.46 to 0.76]).

**DISCUSSION**

Students enrolled in kindergarten who had ≥4 medical visits with comprehensive POHS before their third birthday experienced fewer caries than those who did not receive these services. Previous studies of NC’s POHS program have provided circumstantial evidence of improved oral health status on the basis of administrative claims, including a reduction in dental caries–related treatments and Medicaid payments up to 6 years of age.18,19 This study provides the first empirical evidence that comprehensive POHS provided by physicians in nondental primary care settings as part of a statewide Medicaid benefit reimbursement policy are associated with a reduction in dental caries in children.

The reduction in average adjusted dmft score per child was 0.39 (0 visits = 2.21, ≥4 visits = 1.82), which is a 17.7% reduction. Although the difference between groups is statistically significant, it is difficult to assign clinical meaning at the individual level. This percentage reduction is within the range observed among randomized...
TABLE 2 Select ZINB Model Results Used to Estimate the Adjusted Overall Mean Number of dmft and dt

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Number of dmft</th>
<th>Number of dmft</th>
<th>Number of dmft</th>
<th>Number of dt</th>
<th>Number of dt</th>
<th>Number of dt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logit Estimating Odds of Excess Zero dmft</td>
<td>NB Estimating Expected Number of dmft for Children at Risk of dmft</td>
<td>Difference in Predicted Marginal Mean dmft, ME (95% CI)</td>
<td>Logit Estimating Odds of Excess Zero dt</td>
<td>NB Estimating Expected Number of dt for Children at Risk of dt</td>
<td>Difference in Predicted Marginal Mean dt, ME (95% CI)</td>
</tr>
<tr>
<td>Number of visits (reference group = 0 visits)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.98 (0.88 to 1.08)</td>
<td>0.99 (0.94 to 1.05)</td>
<td>0.01 (−0.13 to 0.14)</td>
<td>0.91 (0.79 to 1.05)</td>
<td>0.95 (0.85 to 1.05)</td>
<td>0.0004 (−0.0685 to 0.0692)</td>
</tr>
<tr>
<td>2</td>
<td>1.11 (0.98 to 1.26)</td>
<td>0.96 (0.90 to 1.03)</td>
<td>−0.19* (−0.32 to −0.05)</td>
<td>0.97 (0.80 to 1.18)</td>
<td>0.87* (0.77 to 0.97)</td>
<td>−0.03* (−0.18 to −0.003)</td>
</tr>
<tr>
<td>3</td>
<td>0.97 (0.81 to 1.17)</td>
<td>0.95 (0.86 to 1.05)</td>
<td>−0.09 (−0.28 to 0.11)</td>
<td>0.93 (0.72 to 1.19)</td>
<td>0.97 (0.81 to 1.16)</td>
<td>0.01 (0.11 to 0.13)</td>
</tr>
<tr>
<td>≥4</td>
<td>1.07 (0.78 to 1.47)</td>
<td>0.84* (0.76 to 0.94)</td>
<td>−0.39** (−0.68 to −0.11)</td>
<td>0.96 (0.72 to 1.30)</td>
<td>0.77 (0.55 to 1.09)</td>
<td>−0.16 (−0.35 to 0.05)</td>
</tr>
</tbody>
</table>

Additional explanatory variables not presented in this table are described in the Methods section. *P < .05, **P < .01. OR, incidence rate ratio; ME, marginal effect based on “average predicted value” method; NB, negative binomial; OR, odds ratio.
and referral process.\textsuperscript{11, 40} Pediatricians can identify children with cavitated lesions with an acceptable level of accuracy, but they are less accurate in identifying and assessing individual risk factors\textsuperscript{13, 14, 44, 45} and tend to underrefer.\textsuperscript{46, 47} Nationally, approximately half of pediatricians screen most patients for caries.\textsuperscript{13} Although physicians are more likely to refer infants and toddlers with obvious disease, dentists prefer that they refer before disease is present.\textsuperscript{48} Finally and importantly, evidence supports the conclusion that primary care referrals increase the use of dental homes, but that they are only partially effective in achieving continuity of care between medical and dental settings.\textsuperscript{49}

Our assessment of the literature and results of this study lead us to conclude that multifaceted interventions targeted to the referral process along with rigorous evaluation of these efforts are needed to help ensure an effective outcome. Recently, this problem has received increased focus at the state and national levels.\textsuperscript{50–52} A long list of potential interventions has been proposed, including the following: training physicians and dentists to use risk-based referral guidelines, development and monitoring of performance measures, incorporation of oral health risk status indicators in electronic health records, and online training approved for continuing medical education. The lack of information on the feasibility and effectiveness of these proposed strategies provides the basis for an extensive research agenda for screening and referral by physicians.

The individual risk profile of children who did and did not receive POHS is unknown, and these differences may bias outcomes. We adjusted for potential confounders, but unobserved differences could still bias the results. Some evidence from other studies suggests that POHS are more likely to be received by children at high risk of caries, because POHS visits are more likely to be made by nonwhites, by Hispanics, in counties with fewer dentists, and in more rural counties, all risk factors for dental caries.\textsuperscript{17} In 1 study, the strongest predictor of follow-up visits was among those who reported that their child went to bed with a bottle or sippy cup.\textsuperscript{53}

CONCLUSIONS

Physician-based POHS can help improve the oral health of children. Medical visits with POHS were associated with a reduction in overall mean dmft in children. We found no difference in the overall mean number of dt between those with and
without POHS, suggesting that families continue to face barriers to obtaining dental treatment of young children. On the basis of evidence of effectiveness observed in this study, enhanced efforts should be taken to expand the delivery of comprehensive POHS in medical settings, particularly in those communities where access to dentists remains limited. Furthermore, development and testing of strategies to improve the linkage between medical and dental offices are needed to ensure the continuity of care for those children receiving POHS in medical settings.

**ABBREVIATIONS**

CI: confidence interval  
dmft: untreated decayed, missing, and filled teeth  
IPTW: inverse probability of treatment weight  
NC: North Carolina  
POHS: preventive oral health services  
USPSTF: US Preventive Services Task Force  
ZINB: zero-inflated negative binomial

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