Effectiveness of Preventive Dental Visits in Reducing Nonpreventive Dental Visits and Expenditures

AUTHORS: Bisakha Sen, PhD,[a] Justin Blackburn, PhD,[a] Michael A. Morrisey, PhD,[a] Meredith L. Kilgore, PhD,[a] David J. Becker, PhD,[a] Cathy Caldwell, MPH,[b] and Nir Menachemi, PhD, MPH[a]

[a]Department of Health Care Organization and Policy, and Lister Hill Center for Health Policy, University of Alabama at Birmingham School of Public Health, Birmingham, Alabama; and [b]Alabama Department of Public Health, Bureau of Children's Health Insurance, Montgomery, Alabama

KEY WORDS

children's health, CHIP, dental expenditures, preventive dental care

ABBREVIATIONS

BCBSAL—Blue Cross and Blue Shield of Alabama
CHIP—Children's Health Insurance Program
ED—emergency department
FPL—federal poverty level
RUCA—rural urban commuting area

Dr Sen conceptualized the study and drafted the initial manuscript; Dr Blackburn designed the study, conducted data analysis, and approved the final manuscript; Drs Morrisey, Kilgore, and Becker reviewed and revised the manuscript, and approved the final manuscript; Ms Caldwell conceptualized the study and approved the final manuscript; and Dr Menachemi conceptualized study, critically reviewed the manuscript, and approved the final manuscript.

www.pediatrics.org/cgi/doi/10.1542/peds.2012-2586

doi:10.1542/peds.2012-2586

Accepted for publication Feb 25, 2013

Address correspondence to Justin Blackburn, PhD, 1665 University Blvd, Room 330K, Birmingham, AL 35294. E-mail: jblackburn@uab.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: *The authors have indicated they have no financial relationships relevant to this article to disclose.*

FUNDING: This work was supported by the Alabama Department of Public Health, Bureau of Children's Health Insurance.

WHAT'S KNOWN ON THIS SUBJECT: Early preventive pediatric dental visits are widely recommended. However, the effectiveness of pediatric preventive dental visits in reducing the need for subsequent, more expensive oral health treatment has not been well established.

WHAT THIS STUDY ADDS: Using an econometric method that accounts for time-invariant differences between children, and thus helps mitigate selection bias, we found a positive impact of preventive dental visits on oral health. However, there is less evidence regarding the cost-effectiveness of preventive visits.

abstract

FREE

BACKGROUND AND OBJECTIVE: Although preventive dental visits are considered important for maintaining pediatric oral health, there is relatively little research showing that they reduce subsequent nonpreventive dental visits or costs. At least 1 study seemed to find that early preventive dental care is associated with more restorative and emergency visits. Previous studies are limited by their inability to account for unmeasurable factors that may lead children to "select" into using both more preventive and nonpreventive dental care. We used econometric techniques that minimize selection bias to assess the effectiveness of preventive dental care in reducing subsequent nonpreventive dental service utilization among children.

METHODS: Using data from Alabama's Children's Health Insurance Program (CHIP), 1998–2010., a cohort study of children's dental service utilization was conducted. Outcomes were 1-year lagged nonpreventive dental care and expenditures, and overall dental and medical expenditures. Children who were continuously enrolled for at least 3 years were included. Separate models were estimated for children aged <8 years (n = 14 972) and those aged ≥8 years (n = 21 833).

RESULTS: More preventive visits were associated with fewer subsequent nonpreventive dental visits and lower nonpreventive dental expenditures for both groups. However, more preventive visits did not reduce overall dental or medical (inclusive of dental) expenditures.

CONCLUSIONS: Preventive dental visits can reduce subsequent nonpreventive visits and expenditures for children continuously enrolled in CHIP. However, they may not reduce overall program costs. Effective empirical research in this area must continue to address unobserved confounders and selection issues. *Pediatrics* 2013;131:1107–1113

Poor oral health is 1 of the most common health conditions of childhood in the United States. Dental caries are 5 times more prevalent than asthma among children ages 5 to 17 years,[1] low-income children are at a particularly high risk of poor oral health,[1–4] and poor oral health is associated with chronic pain and diminished quality of life.[5–7] Untreated dental caries can result in complications leading to emergency department (ED) visits for pediatric dental care and inpatient admissions.[8]

Conventional wisdom among the dental and public health communities presumes that preventive dental care is "the cornerstone of optimal oral health promotion,"[9] that such preventive dental care is cost-effective,[10] and that timely preventive and restorative services can reduce the need for the considerably more expensive ED or inpatient treatment of dental problems.[8,11] These beliefs imply that public health programs such as Medicaid and Children's Health Insurance Programs (CHIP) may produce cost savings by promoting preventive dental care utilization among its enrollees. In reality, there is surprisingly little evidence that preventive dental visits, including early preventive dental visits, are linked with reduced usage of nonpreventive dental services, pediatric dental care ED visits, or program cost savings. One article by Savage et al[12] involving Medicaid-enrolled children in North Carolina has been described as providing "seminal" evidence of the effectiveness and cost-effectiveness of early preventive dental care,[13] was used in a policy brief on early preventive dental care promoted by the Centers for Disease Control and Prevention,[10] and continues to be cited as evidence of cost-effectiveness of pediatric preventive dental care in public insurance programs.[14] However, that study actually found that children in the sample who received their first preventive visit before the age of 1 year (23 of 9204) showed no statistical difference in subsequent dental outcomes compared with the rest of the sample. Children who received their first preventive visit between ages 1and 2 years, or between ages 2 and 3 years, had significantly higher use of restorative and emergency dental services compared with children who had their first preventive visit at age 3 years or later.[12] Furthermore, the authors arrived at the conclusion that dental costs increase linearly with age of first preventive care by limiting their analyses to children who actually used dental services, inexplicably omitting the large number of children who had no preventive, restorative, or emergency dental costs. A more recent study,[15] also using data for Medicaid enrollees from North Carolina, found no effects of early preventive dental care per se on subsequent dental outcomes at 42 to 72 months of age; only early preventive visits accompanied by >2 restorative treatments were associated with subsequent better dental outcomes and lower treatment expenditures.

The central challenge in analyzing the effectiveness of preventive dental care, which served as a limitation in the aforementioned studies, is accounting for unmeasured differences between children that may cause some children to "select" into using more preventive and nonpreventive dental services (relative to their counterparts). For instance, the empirical findings from Savage et al[12] do not imply that starting preventive dental care between ages 1 and 3 years causally increases the need for subsequent restorative or emergency dental procedures. Rather, these results are likely driven by unmeasured factors that introduce selection bias. Children who receive preventive dental care from early ages may have parents who are heavy consumers of medical care. Alternatively, children with a family history of poor dental health, or with special health needs, may use higher levels of all dental care. The question that we would ideally like to answer is whether a child's receipt of (more) preventive dental care reduces the need for nonpreventive dental services compared with what services that same child would have required had he or she not received the preventive dental care. To the best of our knowledge, this is the first article in the pediatric preventive dental care literature that uses established econometric techniques to control for unmeasured differences between children that underlie the selection problem inherent in previous studies. We present these results alongside the results of a set of "naive" analyses that do not account for time-invariant differences in an effort to highlight how each approach can yield different conclusions regarding the effectiveness of preventive dental care.

METHODS

The study population was derived from enrollees in Alabama's CHIP, ALL Kids, which is a stand-alone program distinct from the state's Medicaid program. ALL Kids provides coverage for Alabama residents aged <19 years with family incomes from 101% to 200% of the federal poverty level (FPL). Beginning in the federal fiscal year 2010, the program expanded to cover children up to 300% of the FPL. The program is administered by Blue Cross and Blue Shield of Alabama (BCBSAL), and children enrolled in ALL Kids benefit from full medical, pharmaceutical, and dental coverage from the BCBSAL preferred provider network. Enrollees pay an annual premium and experience cost sharing in the form of copayments for selected services. Preventive and diagnostic dental care is not subject to copayments.

The data for this study were obtained from claims administered for ALL Kids by BCBSAL beginning October 1, 1998, through December 31, 2010. Enrollment history data, also from BCBSAL, provided information regarding enrollees' demographic characteristics such as age, race, gender, and cost-sharing group, which corresponds to FPL (101%–150% are considered the "low-fee group"; 151%–300% the "fee group"; and a federally exempt group, primarily children of Native American descent, comprises the "no-fee group"). Geographic location was based on zip codes maintained by ALL Kids, which were converted to rural urban commuting area (RUCA) codes (http://depts.washington.edu/uwruca/) to measure rural/urban status. Claims data were used to identify children diagnosed with chronic health conditions (based on predefined specifications by ALL Kids).[16]

Our empirical method requires repeated observations from the same child. Hence, children included in our sample were required to have a minimum of 3 years' continuous enrollment in ALL Kids, with no gaps in coverage >1 month. In addition, we excluded from our analysis children with previous sporadic episodes of enrollment in ALL Kids before their 3-year period of continuous enrollment. A further inclusion criterion was the absence of any dental claims beyond preventive care in the first year of continuous enrollment. For example, children receiving restorative dental care in their first year of enrollment were excluded. In our analyses, the effect of preventive care on the defined outcomes was evaluated in the subsequent enrollment period. In other words, a preventive visit in a child's t^{th} enrollment year was predicted to have an effect on the $(t+1)^{th}$ enrollment year's dental claims.

Preventive dental visits were defined as a claim filed by a dentist's office with a Code on Dental Procedures and Nomenclature procedure code of D1000 through D1999, which is consistent with the Healthcare Effectiveness Data and Information Set definition of preventive dental care.[17] In some cases, restorative services were used during a preventive visit. Hence, "preventive + restorative" visits were classified as such if, along with preventive services, claims were also filed for restorative dental services (D2000–D2999). The outcome of nonpreventive dental visits included those with restorative (D2000–D2999), endodontic (D3000–D3999), periodontic (D4000–D4999), and/or all other dental (D5000–D7999, D9000–D9999) procedures. In addition, emergency dental visits were included and defined as a dental visit paired with code D0140 or as a medical claim with a primary *International Classification of Diseases, Ninth Revision,* diagnosis codes 521, 522, 523, 525.3, 525.9, or 528. Costs for preventive procedures and outcomes were calculated based on the sum of a specific type of procedure over the annual enrollment period, adjusted for inflation to year 2010 dollars. Medical expenditures included the total cost of all medical services for the enrollment period, excluding pharmaceuticals. Medical expenditures were also an outcome of interest because they help provide a more comprehensive view of the potential impact of preventive dental care.

Empirical Model

The "naive" model in this case is:

$$Y_{jt} = \alpha + PD_{jt-1}\beta + X_{jt}\lambda + u_{jt} \qquad (1)$$

where Y represents the outcome of interest (eg, nonpreventive dental visits or program expenditures for such visits) for the j^{th} enrollee in the t^{th} year; PD represents the number of preventive dental visits by the enrollee in year t-1 and the binary indicator for whether any restorative services were performed during any of those preventive visits (preventive + restorative); and $\boldsymbol{X}_{jt}$ represents a vector of observable characteristics for the enrollee. As we explain in the Appendix, this model cannot account for unmeasured child-specific factors (including characteristics of the child's parents) that may drive selection into using higher levels of preventive and nonpreventive services. As a result, the coefficient estimate of PD_{jt-1} obtained from this model will be biased and thereby provide virtually no useful information on the association between preventive dental visits and the outcome of interest. Hence, we refer to this as the naive specification.

Our preferred specification is the model referred to in econometrics as the individual fixed effects (FE) model.[17,18] Empirical details are also provided in the Appendix. Essentially, this method is equivalent to using each child as his or her own control, and it permits researchers to test whether the same child has different levels of nonpreventive dental visits or expenditures after the years where they had more preventive dental visits compared with the years when they had fewer or none. $\mathbf{X}_{jt}$ continues to control for observable, time-varying predictors, including the child's age, cost-sharing group, chronic condition diagnosis, rural/urban status according to RUCA, and calendar year. However, child characteristics such as race, gender, parental attitudes toward dental care, genetic factors, and environmental exposures that are largely time-invariant (ie, do not change for a given child over the time they are observed) are now absorbed in the FE. SEs are clustered to account for repeat observations from the same child.

Models were estimated separately for children aged <8 years (younger children) and children aged ≥8 years (older children). Extant studies largely focus on outcomes for children aged ≤7 years. However, oral health for older children remains a concern to policy makers,[1] and the efficacy of preventive dental care in reducing subsequent nonpreventive expenditures among older children should be of interest to Medicaid and CHIP administrators.

RESULTS

Our final samples included 14 972 children aged <8 years (with 34 491 pooled child-year observations) and 21 833 children aged ≥8 years (with 76 716 pooled child-year observations). Demographic and other characteristics for both age groups are presented in Table 1. Table 2 provides sample means of the outcomes of interest; namely, number of nonpreventive dental visits, nonpreventive dental expenditures, medical expenditures without dental costs, and all dental and all medical expenditures. The proportion of child-year observations with 0, 1, 2, and ≥3 preventive visits, as well as preventive + restorative visits, are also given in Table 2.

Results from the naive models and the FE models for the younger children are displayed in Table 3. Variables measuring preventive dental visits and preventive + restorative care are the key explanatory variables. All enrollee characteristics listed in Table 1 are controlled for in the models. The naive models show that, compared with 0 preventive dental visits, having 1, 2, or ≥3 preventive visits in the previous period was associated with having more nonpreventive dental visits (β = 0.10, 0.15, and 0.18, respectively; $P <$ .01 in all cases). Preventive + restorative visits were associated with additional nonpreventive dental visits (β = 0.10, $P <$ .01). The results from the FE analyses are very different, indicating that, compared with 0 preventive dental visits in the past year, having 1, 2, or ≥3 preventive visits was associated with fewer nonpreventive dental visits (β = –0.18, –0.29, and –0.57, respectively; $P <$ .01 in all cases), and preventive + restorative care further reduced subsequent nonpreventive visits (β = –0.42, $P <$ .01). Likewise, the naive model either found no associations between preventive visits subsequent to nonpreventive dental expenditures or positive associations in case of 1 preventive visit (β = 15.54, $P <$ .01), or preventive + restorative care (β = 18.36, $P <$ .05). In contrast, FE models showed that more preventive visits are associated with lower subsequent nonpreventive expenditures (β = –32.38, –48.57, and –53.61, $P <$ .01), as is preventive + restorative care (β = –99.72, $P <$ .01). Results for older children (Table 4) follow a very similar pattern.

The contrast in results from the 2 model specifications strongly indicates the presence of time-invariant child-specific confounders, affirming that estimates from the naive models are biased and yield little useful information regarding the effectiveness of preventive dental visits. Therefore, we only focused on results from the preferred FE models for the remaining outcomes.

No statistical associations were seen between preventive dental visits and subsequent medical (excluding dental) expenditures for younger children. For older children, a positive association existed between 2 preventive visits and subsequent medical expenditure. Importantly, although the preferred FE models showed that more preventive dental visits were associated with fewer subsequent nonpreventive dental visits and lower expenditures, it does not seem that the decreases in expenditures are large enough to offset the program expenditures due to more frequent preventive visits. In FE models in which overall dental expenditures are the

TABLE 1 Demographic Characteristics for Study Samples

Variable	Aged <8 Years (n = 14 972)	Aged ≥8 Years (n = 21 833)
Age at first observation, mean (SD), y	4.26 (2.27)	11.49 (2.43)
Male	7686 (51.34)	11 375 (52.10)
Race		
White	9650 (64.45)	12 304 (56.36)
African American	4205 (28.09)	8415 (38.54)
Other	1117 (7.46)	1114 (5.10)
Fee group		
Low fee	7365 (49.19)	15 895 (72.80)
Fee	7461 (49.83)	5801 (26.57)
No fee	99 (0.66)	99 (0.45)
High fee	47 (0.31)	38 (0.17)
Rural/urban code		
Urban	10 090 (67.39)	13 912 (63.72)
Large rural area	1748 (11.68)	2910 (13.33)
Small rural area	1807 (12.07)	2697 (12.35)
Isolated	1202 (8.03)	2188 (10.02)
Location unknown	125 (0.83)	126 (0.58)
Chronic disease	3989 (26.64)	5195 (23.79)
Periods of enrollment		
2	5597 (37.38)	8465 (38.77)
3	3230 (21.57)	4659 (21.34)
≥4	6145 (41.04)	8709 (39.89)

The descriptive statistics show the mean (SD) for age; for categorical variables such as gender and race, the number of respondents in the category are given as well as percentage of the full sample.

TABLE 2 Summary Statistics for Outcome Variables and Preventive Dental Visits, Pooled Sample

Variable	Age Group	
	<8 Years (*n* = 34 491 person-years)	≥8 Years (*n* = 76 716 person-years)
Average nonpreventive dental visits per person-year	0.64	0.54
Average nonpreventive dental expenditures per person-year	$72.92	$84.63
Average dental expenditures per person-year	$152.81	$188.21
Average medical expenditures per person-year	$1003.38	$1020.40
No. (%) of preventive visits		
0	17 737 (51.4)	29 975 (39.1)
1	7737 (22.4)	21 752 (28.4)
2	7782 (22.6)	21 682 (28.3)
≥3	1235 (3.6)	3307 (4.3)
No. (%) of preventive + restorative visits	1378 (4.0)	3993 (5.2)

The descriptive statistics are based on pooled child-year observations. In addition, we found that the average cost for a preventive visit was $104.45, preventive + restorative care was $408.15, and the average cost for a nonpreventive visit was $141.42.

TABLE 3 Association Between Preventive Dental Visits and Nonpreventive Dental Visits, Expenditures, and Overall Expenditures for Children Aged <8 Years: Naive and FE Results

Variable	Model	1 Preventive Visit	2 Preventive Visits	≥3 Preventive Visits	Preventive + Restorative Care
		β	β	β	β
Nonpreventive dental visits	Naive	0.17***	0.11***	0.09*	0.19***
Nonpreventive dental visits	FE	−0.18***	−0.29***	−0.57***	−0.42***
Nonpreventive dental expenditures	Naive	15.54***	0.72	−3.74	18.36*
Nonpreventive dental expenditures	FE	−32.38***	−48.57***	−53.61***	−99.72***
Medical expenditures (excluding dental)	FE	3.15	27.13	127.68	−108.30
All dental expenditures	FE	62.28***	126.31***	212.57***	164.57***
All medical expenditures (including dental)	FE	65.43	153.44§	340.24§	56.27

N = 34 491 child-year observations. The sample includes observations on all Alabama CHIP enrollees aged <8 years, with 3 continuous periods of enrollment after initial enrollment, and no nonpreventive dental visits in very first enrollment period. The reference category for preventive visits is "0 preventive visits." "Preventive + restorative" is a binary indicator for whether restorative claims were filed alongside preventive claims in any visits. Nonpreventive visits were defined as visits having at least 1 dental procedure but excluding all preventive procedures. All expenditures are in inflation-adjusted 2011 dollars. All models controls for FPL category, age, race, gender, chronic condition diagnosis, RUCA, and calendar year. However, in the FE models, time-invariant characteristics, such as gender and race, are automatically subsumed into the FE. All models were run by using Stata version 11 (Stata Corp, College Station, TX).
§ $P < .10$; * $P < .05$; ** $P < .01$; *** $P < .001$.

TABLE 4 Association Between Preventive Dental Visits and Nonpreventive Dental Visits, Expenditures, and Overall Expenditures for Children Aged ≥8 Years: Naive and FE Regression Results

Variable	Model	1 Preventive Visit	2 Preventive Visits	≥3 Preventive Visits	Preventive + Restorative Care
		β	β	β	β
Nonpreventive dental visits	Naive	0.10***	0.08***	0.07**	0.09***
Nonpreventive dental visits	FE	−0.22***	−0.32***	−0.36***	−0.36
Nonpreventive dental expenditures	Naive	15.27***	8.77***	2.97	10.69*
Nonpreventive dental expenditures	FE	−25.67***	−37.95***	−46.00***	4.85
Medical expenditures (excluding dental)	FE	89.64§	128.18*	149.42	−79.86
All dental expenditures	FE	90.94***	161.32***	245.02***	172.34***
All medical expenditures (including dental)	FE	180.59***	289.51***	394.44***	92.48

N = 76 716 child-year observations. The sample includes observations on all Alabama CHIP enrollees aged ≥8 years, with 3 continuous periods of enrollment after initial enrollment, and no nonpreventive dental visits in the first enrollment period. The reference category for preventive visits is "0 preventive visits." "Preventive + restorative" is a binary indicator for whether restorative claims were filed alongside preventive claims in any visits. Nonpreventive visits were defined as visits having at least 1 dental procedure but excluding all preventive procedures. All expenditures are in inflation-adjusted 2011 dollars. All models controlled for FPL category, age, race, gender, chronic condition diagnosis, RUCA, and calendar year. However, in the FE models, time-invariant characteristics, such as gender and race, are automatically subsumed into the FE. All models were run by using Stata version 11 (Stata Corp, College Station, TX).
§ $P < .10$; * $P < .05$; ** $P < .01$; *** $P < .001$.

outcomes, results indicate that more preventive dental visits, and preventive + restorative care, are associated with higher expenditures for younger (β = 62.28, 126.31, 212.57, and 164.57; $P < .01$ in all cases) and older (β = 90.94, 161.33, 245.02, and 172.34; $P < .01$) children. For overall medical expenditures (inclusive of dental), among older children, more preventive dental visits were associated with significantly higher expenditures (β = 180.59, 289.51, and 394.44; $P < .01$), although preventive + restorative care was not.

DISCUSSION

It is often surmised that preventive dental care is effective and cost-effective because it reduces the need for subsequent, more expensive dental treatments,[8,10,11] but actual empirical support for this assumption is fairly limited. However, demonstrating the effects of preventive care is important, especially given the expansions in coverage of comprehensive dental benefits that occurred under the Children's Health Insurance Program Reauthorization Act.[19] Two previously discussed studies[12,15] using data from North Carolina found minimal evidence that having early preventive dental care reduces subsequent restorative or emergency dental visits. Two other (unpublished) studies using data from Wisconsin and Michigan failed to find evidence that preventive dental care reduces subsequent poor dental health outcomes for children.[20,21]

All of the aforementioned studies are limited by their inability to control for unobserved child-specific factors that can potentially cause some children (children's parents) to select into utilizing more preventive and more nonpreventive dental care. Our study contributes substantially to this literature by applying the individual FE regression method to control for all time-invariant child-level factors that might drive such selection. The substantial differences we found in estimates from our FE models versus the naive specifications emphasize the limitations of studies that fail to control for such unobserved heterogeneity. Also, our study considered older children in addition to younger children, whereas the extant literature on preventive dental care mostly focuses on the latter.

Using data on CHIP enrollees in Alabama, we found that preventive dental visits reduce a child's subsequent nonpreventive dental visits and expenditures compared with years when the same child had no preventive visits. Restorative services obtained during preventive visits further reduced subsequent nonpreventive dental visits and expenditures, which is similar to findings by Beil et al.[15] This finding holds for younger and older children. However, we found no evidence that preventive dental visits generate net savings for the program, at least in the 2-year follow-up period of our study. Although nonpreventive dental expenditures were lower when children had more preventive visits, overall dental expenditures (the sum of nonpreventive and preventive) and medical costs inclusive of dental expenditures were higher with more preventive visits.

The study has important limitations. One tradeoff in using the FE method is that we cannot estimate outcomes associated with obtaining preventive dental care at a specific age versus later. Also, our findings cannot inform on any long-run health benefits or savings with preventive dental visits. We lacked information on whether the children reside in communities with communal water fluoridation, which can reduce dental caries.[11] We also lacked information on quality of care received during preventive dental visits, including whether they received fluoride varnishes, which can also help prevent dental caries,[22–25] and variation in decisions made by their dentists regarding restorative care.[26] Furthermore, we cannot measure the extent of unmet oral health needs among children in our sample who are not observed to use any dental services. Our sample only includes children >100% of FPL, with 3 years of continuous enrollment (which can suggest greater family stability), who did not use nonpreventive dental services in the first enrollment year. Hence, it is possible that these children may be at relatively moderate risk of caries compared with children <100% FPL or those enrolled in ALL Kids briefly and sporadically. We thus caution against generalizing the results to all low-income children. Finally, there are the usual concerns about generalizability because our study was based on 1 state's data.

CONCLUSIONS

Concerns have been expressed about the low use of preventive pediatric dental care services by children in public insurance programs.[8,27] Our findings indicate that children require fewer nonpreventive dental services when they have more preventive visits, indicating that preventive services do improve oral health. Thus, although we did not find that preventive dental visits resulted in overall program cost savings to ALL Kids, these visits may be beneficial from a societal point of view when taking into account potential improvements in quality of life of the child enrollees due to fewer oral health problems. At the same time, there is a clear need for continued scientific research into the effectiveness of pediatric preventive dental care so as to better inform public health policy.

APPENDIX

The "naive" model described in the main article is:

$$Y_{jt} = \alpha + PD_{jt-1}\beta + X_{jt}\lambda + u_{jt} \qquad (1)$$

where *Y* represents the outcome of interest for the j^{th} enrollee in the t^{th} year; *PD* represents the number of preventive dental visits by the enrollee in year t-1; and X_{jt} represents a vector of observable characteristics for the enrollee.

In this model, any child-specific factor (including characteristics of the child's parents) that is not captured in X_{jt}, and that potentially influences the child's preventive and nonpreventive dental service utilization, will be in the error term u_{jt}. The presence of such factors violates the condition of $Cov(PD_{jt-1}, u_{jt}) = 0$, which is the necessary condition to obtain an unbiased estimate of β. Therefore, it would no longer be the case that the expected value of the estimated coefficient of PD_{jt-1} accurately reflects the actual population coefficient. This is typically referred to as "omitted variable bias," and it implies that the results can reflect a spurious relationship between PD_{jt-1} and Y_{jt}.

The individual FE model operates using the following specification

$$Y_{jt} = \alpha + PD_{jt-1}\beta + X_{jt}\lambda + u_{jt} \qquad (2)$$

where $u_{jt} = v_j + \varepsilon_{jt}$

$Cov(PD_{jt-1,\, v_j}) \neq 0$.

Namely, this model explicitly assumes that there is an unmeasured component "v_j" in the error term that is specific to each child j, which is time-invariant for the period the child is observed and which is correlated to PD_{jt-1}. Thus, the estimation technique essentially controls for the presence of v_j by using within-child differences. This method removes all potential omitted variable bias from time-invariant child-specific (or parent-specific) heterogeneity whereby some children select into using both more preventive and nonpreventive services, and it provides a much more accurate estimate of the true relationship between PD_{jt-1} and Y_{jt}.

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. Edelstein BL, Manski RJ, Moeller JF. Pediatric dental visits during 1996: an analysis of the federal Medical Expenditure Panel Survey. *Pediatr Dent*. 2000;22(1):17–20
3. Kenney GM, Ko G, Ormond BA. *Gaps in Prevention and Treatment: Dental Care for Low Income Children*. Washington, DC: The Urban Institute; 2000. Assessing the New Federalism; Policy Brief B-15.April 2000. Available at: www.urban.org/publications/309527.html. Accessed February 1, 2013
4. Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III, 1988-1994. *J Am Dent Assoc*. 1998;129(9):1229–1238
5. Jackson SL, Vann WF Jr, Kotch JB, Pahel BT, Lee JY. Impact of poor oral health on children's school attendance and performance. *Am J Public Health*. 2011;101(10):1900–1906
6. Peterson J, Niessen L, Nana Lopez GM. Texas public school nurses' assessment of children's oral health status. *J Sch Health*. 1999;69(2):69–72
7. Schechter N. The impact of acute and chronic dental pain on child development. *Southeastern Society of Pediatric Dentistry*. 2000;6(2):16–17
8. Ladrillo TE, Hobdell MH, Caviness AC. Increasing prevalence of emergency department visits for pediatric dental care, 1997-2001. *J Am Dent Assoc*. 2006;137(3):379–385
9. Lewis CW, Johnston BD, Linsenmeyar KA, Williams A, Mouradian W. Preventive dental care for children in the United States: a national perspective. *Pediatrics*. 2007;119(3). Available at: www.pediatrics.org/cgi/content/full/119/3/e544
10. Sinclair SA, Edelstein B. Cost effectiveness of preventive dental services. Children's Dental Health Project Policy Brief. Available at: www.cdc.gov/oralhealth/publications/library/burdenbook/pdfs/CDHP_policy_brief.pdf. Accessed February 1, 2013
11. Pettinato ES, Webb MD, Seale NS. A comparison of Medicaid reimbursement for non-definitive pediatric dental treatment in the emergency room versus periodic preventive care. *Pediatr Dent*. 2000;22(6):463–468
12. Savage MF, Lee JY, Kotch JB, Vann WF Jr. Early preventive dental visits: effects on subsequent utilization and costs. *Pediatrics*. 2004;114(4). Available at: www.pediatrics.org/cgi/content/full/114/4/e418
13. Lee JY, Bouwens TJ, Savage MF, Vann WF Jr. Examining the cost-effectiveness of early dental visits. *Pediatr Dent*. 2006;28(2):102–105, discussion 192–198
14. Chi DL, Momany ET, Jones MP, et al. Relationship between medical well baby visits and first dental examinations for young children in Medicaid. *Am J Public Health*. 2013;103(2):347–354
15. Beil H, Rozier RG, Preisser JS, Stearns SC, Lee JY. Effect of early preventive dental visits on subsequent dental treatment and expenditures. *Med Care*. 2012;50(9):749–756
16. Becker DJ, Blackburn JL, Kilgore ML, et al. Continuity of insurance coverage and ambulatory care-sensitive hospitalizations/ED visits: evidence from the children's health insurance program. *Clin Pediatr (Phila)*. 2011;50(10):963–973
17. National Committee for Quality Assurance (NCQA). *HEDIS 2011: Technical Specifications*. Washington, DC: National Committee for Quality Assurance; 2010
18. Allison P. Introduction to fixed effects methods. In: *Fixed Effects Regression Methods for Longitudinal Data Using SAS* [computer program]. Cary, NC: SAS Institute, Inc; 2005:1–8
19. The Kaiser Family Foundation's Commission on Medicaid and the Uninsured. Children's oral health benefits. CHIP Tips, March 2010. Available at: www.kff.org/medicaid/upload/8054.pdf; Accessed: May 15, 2012
20. Snyder A. Early preventive dental care: the Wisconsin experience. Presented at: National Oral Health Conference; April 28-May 1, 2007; Denver, CO
21. Sohn W, Lim S, Ismail AI. Effects of early preventive dental visits among Medicaid enrolled children. Presented at: International Association for Dental Research General Session & Exhibition; July 1–5, 2008; Toronto, ON, Canada
22. Arruda AO, Senthamarai Kannan R, Inglehart MR, Rezende CT, Sohn W. Effect of 5% fluoride varnish application on caries among school children in rural Brazil: a randomized controlled trial. *Community Dent Oral Epidemiol*. 2012;40(3):267–276
23. Autio-Gold JT, Courts F. Assessing the effect of fluoride varnish on early enamel carious lesions in the primary dentition. *J Am Dent Assoc*. 2001;132(9):1247–1253, quiz 1317–1318
24. Holm AK. Effect of fluoride varnish (Duraphat) in preschool children. *Community Dent Oral Epidemiol*. 1979;7(5):241–245
25. Klein SP, Bohannan HM, Bell RM, Disney JA, Foch CB, Graves RC. The cost and effectiveness of school-based preventive dental care. *Am J Public Health*. 1985;75(4):382–391
26. Bader JD, Shugars DA. Variation in dentists' clinical decisions. *J Public Health Dent*. 1995;55(3):181–188
27. Mouradian WE, Wehr E, Crall JJ. Disparities in children's oral health and access to dental care. *JAMA*. 2000;284(20):2625–2631

PEDIATRICS
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Effectiveness of Preventive Dental Visits in Reducing Nonpreventive Dental Visits and Expenditures

Bisakha Sen, Justin Blackburn, Michael A. Morrisey, Meredith L. Kilgore, David J. Becker, Cathy Caldwell and Nir Menachemi

Pediatrics 2013;131;1107
DOI: 10.1542/peds.2012-2586 originally published online May 27, 2013;