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RESEARCH ARTICLE

Preventive Dental Care and Long-Term Dental Outcomes among ALL Kids Enrollees

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Objective. To investigate whether early or regular preventive dental visit (PDV) reduces restorative or emergency dental care and costs for low-income children.
Study Setting. Enrollees during 1998–2012 in the Alabama CHIP program, ALL Kids.
Study Design. Retrospective cohort study using claims data for children continuously enrolled in ALL Kids for at least 4 years. Analyses are conducted separately for children 0–4 years, 4–9 years, and >9 years. For 0–4 years, the intervention of interest is whether they have at least one PDV before age 3. For the other two age groups, interventions of interest are if they have regular PDVs during each of the first 3 years, and if they have claims for a sealant in the first 3 years. Outcomes—namely restorative and emergency dental service and costs—are measured in the fourth year. To account for selection into PDV, a high-dimensional propensity scores approach is utilized.
Data Extraction. Claims data were obtained from ALL Kids.
Principal Findings. Only sealants are associated with a reduced likelihood of using restorative and emergency services and costs.
Conclusions. Whether PDVs without sealants actually reduce restorative/emergency pediatric dental services is questionable. Further research into benefits of PDV is needed.
Key Words. Preventive, dental, children, costs

Tooth decay or dental caries is among the most common chronic disease affecting children, and it disproportionately affects low-income children. Dental caries are associated with infectious abscesses, chronic pain, missed school, and an overall reduced quality of life (Gift, Reisine, and Larach 1992; Acs et al. 1999; Peterson, Niessen, and Nana Lopez 1999; Schechter 2000; US Department of Health and Human Services 2000; Jackson et al. 2011). Early and regular preventive dental care is frequently advocated as a means to prevent the onset of dental disease in children, and it is assumed to be cost-effective as it presumably reduces the need for expensive restorative dental treatment, including treatment provided in an Emergency Department (ED; Pettinato, Webb, and Seale 2000; Sinclair and Edelstein 2005; Ladrillo, Hobdell, and Caviness 2006). For example, a policy brief from the Centers for Disease Control and Prevention states, "early and routine preventive dental care, fluoridation and sealants are cost-effective in reducing disease burden and associated expenditures" (Sinclair and Edelstein 2005). However, empirical evidence on this front is relatively scarce and often conflicting (Weintraub et al. 2001; Dasanayake et al. 2003; Savage et al. 2004; Lee et al. 2006; Snyder 2007; Sohn, Lim, and Ismail 2008; Beil et al. 2012). For example, one study (Lee et al. 2006) found that, among North Carolina Medicaid enrollees, children who received their first preventive dental visit (PDV) before age 1 year were statistically no less likely to have a subsequent restorative or ED visit, whereas children with a first PDV between ages 1–2 years or 2–3 years were more likely to have subsequent restorative and ED visits than children who had not received a PDV by that age. A second study using North Carolina Medicaid data (Beil et al. 2012) found no effects of early preventive dental care alone on subsequent dental outcomes through 6 years of age. However, early preventive visits also accompanied by two restorative treatments were associated with subsequent improved dental outcomes and lower treatment costs for the program. Two unpublished reports using data from other states found little evidence of PDV reducing the subsequent treatments or costs (Snyder 2007; Sohn, Lim, and Ismail 2008). However, one study using Alabama Medicaid data that focused specifically on sealants found that Medicaid costs per child for sealants and subsequent restorative care was $56 in the sealant group versus $72 for subsequent care alone in the nonsealant group (Dasanayake et al. 2003). A systematic review of effectiveness of early PDV (Bhaskar, McGraw, and Divaris 2014) was only able to identify four studies

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that met the inclusion criteria, and it concluded that the currently available evidence base supporting effectiveness of such visits was weak and that more research was required.

The finding of positive associations between PDV and later restorative services may be indicative of problems being detected early, or of provider-induced demand. However, there is also the challenge of accounting for "selection bias"—in other words, the possibility that children having early or regular PDV may differ in ways that are harder to measure than children who do not. These unobservable differences may encompass, but are not limited to, parental attitudes about utilizing health care services and family history of poor dental health. Insofar as these unobserved factors are correlated with both preventive and restorative dental services, they may lead to spurious positive associations between PDV and restorative dental services.

One recent article, using data from the Alabama Children's Health Insurance (CHIP) program, addressed the problem of selection bias by using individual fixed-effects regression models. Effectively, this approach provides within-child estimates of the effectiveness of PDV by comparing short-term outcomes for the same child in years when they had (more) PDVs compared to years when they had fewer (or none) (Sen et al. 2013). This approach eliminates bias from those unobserved factors that remain time-invariant for a specific child. Results found that more PDVs were associated with fewer restorative visits and costs in the following year, though the reduced costs were not sufficient to offset the higher PDV costs incurred by the program.

While individual fixed effects are a useful way to address selection bias, they have definite limitations. They rely on time-period to time-period variation in the treatment and the outcome for the same child. Thus, they are of little use if the question of interest is whether starting early PDV before a certain age provides improved outcomes and lower costs over the longrun (e.g., the next 5 years). They are also of little use when evaluating the effectiveness of one-time preventive treatments, like sealants. Therefore, in this study, we explore the long-term effectiveness of early PDV and preventive treatments like sealants by utilizing another empirical tool—high-dimensional propensity scores (HDPSs)—to minimize selection bias. The purpose is to explore whether two separate interventions—at least one PDV per year, and at least one prior sealant treatment—are associated with reductions in the likelihood and costs of nonpreventive dental treatments, restorative dental treatments, and ED dental treatments.

METHODS

We use claims data from the Alabama CHIP program, called ALL Kids, from 1998 through 2012. At the start of our study period, ALL Kids coverage was available to Alabama residents under age 19 with family incomes between 100 and 200 percent of the federal poverty line. Beginning in October 2009, the eligibility level was expanded to 300 percent of the FPL. Enrollees faced annual premiums and copayments which varied across the income groups defined by family income and Native American status. 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. Children in families with incomes between 100 and 150 percent of the FPL (termed the "low-fee group") face lower levels of cost-sharing, while children in families with incomes between 150 and 200 percent of the FPL (termed the "fee group") face higher levels of cost-sharing. Children in the 200–300 percent of the FPL following the expansion in 2009 (termed the "expansion group") have similar cost-sharing as the fee group. The third group, comprised primarily of Native American children ("no fee group"), is federally exempted from all cost-sharing. There are no upfront annual deductibles in the ALL Kids program, and out-of-pocket costs per plan year may not exceed 5 percent of the family income (All Kids Children's Health Insurance Program 2012). Preventive and diagnostic dental care is not subject to copayments for any group.

Analyses are conducted separately for children from birth to 4 years, from 4 years to 9 years, and above 9 years. The prior literature has focused extensively on early PDV, which motivates our analysis of children under 4 years of age. However, regular PDV and the use of sealants are likely to be more prevalent among older children. Only those children who are continuously enrolled in ALL Kids for at least 4 years are included in the analyses. For children under 4 years, the intervention of interest is whether they have at least one PDV during the first 3 years of life. For the other two age groups, the interventions of interest are if they have at least one PDV during each of the first 3 years of continuous enrollment, at least two PDV during each of the first 3 years, and if they have any claims for a sealant in the first 3 years. Supplemental analyses were also done for the intervention of at least one PDV that involved fluoride varnish. Outcomes are measured in the fourth year for each age group. Descriptive statistics summarizing the use of PDV for each of the three age groups are presented in Table 1.

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. 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 2012 dollars.

The primary empirical technique used is the high-dimensional propensity score method (HD-PS). Essentially, the concern here is that children who are PDV users can have characteristics that differ from PDV nonusers—such as different health histories, parental awareness, or parental attitudes about using health services. These differences may influence both the use of preventive and restorative services and thus "bias" the estimated effect of preventive services on our outcomes of interest. Propensity score methods in general attempt to reduce selection bias by "matching" enrollees who receive a treatment to a suitable control group by using observed characteristics, but

Table 1: Dental Use by Different Age Groups of Children Continuously Enrolled in ALL Kids

	% (N)
Dental use by children continuously enrolled in ALL Kids at least 4 years from birth (N = 4,774)	
Type of preventive treatment	
At least 1 preventive visit	56.4 (2,693)
Dental use by children continuously enrolled in ALL Kids at least 4 years aged <9 years (N = 9,172)	
Type of treatment	
1 or more preventive visit per year	49.3 (4,526)
2 or more preventive visit per year	15.2 (1,396)
At least one sealant	29.3 (2,687)
Dental use by children continuously enrolled in ALL Kids at least 4 year aged ≥9 years (N = 23,589)	
Type of treatment	
1 or more preventive visit per year	43.6 (10,285)
2 or more preventive visit per year	11.6 (2,730)
At least 1 sealant	20.4 (4,817)

simplistic "matching" technique using limited characteristics like age, race-ethnicity, gender, area of residence, and so forth is unlikely to adequately capture the underlying differences between utilizers and nonutilizers of PDV. HD-PS methods are designed specifically to maximize the information contained within administrative claims data (Schneeweiss et al. 2009).

Essentially, the HD-PS routine identifies patterns of health service utilization from the claims data and generates variables which serve as measurable proxies for health state and health care utilization (Rosenbaum and Rubin 1983; Hirano and Imbens 2001). The demographic variables included in the propensity score estimation are race, rural–urban commuting code (four levels), FPL, and age. We also include the number of well-child visits as a prespecified variable, defined by Clinical Procedure Terminology (CPT) procedure codes 99381-99385, 99391-99395, 99432, 99461, and ICD9 primary and secondary diagnosis codes V20.2, V20.3, V70.0, V70.5, V70.6, V70.8, V70.9. In addition to demographic and prespecified variables, up to 200 empirically derived variables from the claims dimensions were included into propensity score generation. Specifically, all children meeting continuous enrollment criteria have claims data represented by four dimensions: inpatient diagnoses, outpatient diagnoses, outpatient CPT procedure codes, and pharmaceutical utilization based on American Hospital Formulary System therapeutic class. For diagnoses, individual claims were classified into groups using the Clinical Classification Software. All dental-related diagnoses and well-child visit diagnoses and procedure codes were excluded dimensions.

The distributions of propensity scores are presented in the Appendix. We convert the propensity scores into inverse probability weights (IPW). The IPW are defined as the inverse of the propensity score for the "exposed group," in this case receipt of PDV and the inverse of 1 minus the propensity score for the "unexposed group"—those not receiving PDV. Tables 2, 3, and 4 show raw descriptive statistics and weighted descriptive statistics for enrollees under 4 years, 4 should be ≤9 years, and over 9 years, respectively, to illustrate the extent to which we attain balance between our treatment and control samples following propensity score weighting. Standardized differences were used to compare the PDV versus nonusers of PDV, with ≥10 being indicative of imbalance. Table 5 presents results for the three age groups from "naïve" logistic and OLS regressions where selection bias is not accounted for in any way, followed by results from logistic and OLS regressions where the IPWs are used for weighting the final logistic models (for outcomes), and ordinary least square models (for costs). For all logistic regressions, we present "marginal effects" (i.e., the percentage change in the probability of the

Table 2: Descriptive Statistics for Treatment and Control Groups before and after Propensity Score Weighting: Birth–4 Years

	Raw			*Weighted*		
	No Preventive n = 2,081 (%)	*1+ Preventive n = 2,693 (%)*	*Std. Diff*	*No Preventive n = 2,081 (%)*	*1+ Preventive n = 2,693 (%)*	*Std. Diff*
Male	52.4	50.5	3.8	51.7	51.2	1.0
Age, mean (SD)	4.0 (0.8)	4.5 (0.7)	66.5	4.3 (1.2)	4.3 (1.0)	1.1
White	72.5	67.2	11.6	68.4	69.0	1.3
Black	17.3	23.6	15.7	21.5	21.0	1.2
Other	10.2	9.2	3.4	10.1	10.0	0.3
FPL 100%–150%	27.4	27.0	0.9	28.4	27.0	3.1
FPL 150%–200%	58.9	57.8	2.2	57.4	58.5	2.2
Exempt	1.4	0.8	5.8	1.1	1.0	1.0
Expansion	12.3	14.4	6.2	13.1	13.4	0.9
Urban	67.0	71.7	10.2	69.8	69.9	0.2
Large rural	10.3	10.1	0.7	10.5	10.1	1.3
Small rural	13.1	9.9	10.0	11.1	11.2	0.3
Isolated	7.6	7.0	2.3	7.1	7.2	0.4
Well-child visits, 3 years average per child (SD)	6.6 (3.7)	6.1 (3.7)	13.5	6.3 (5.5)	6.3 (4.9)	5.2

outcome due to the intervention) calculated at the mean level of all other variables.

RESULTS

For the 4,774 enrollees observed from birth through first 4 years of age, 56.4 percent had at least one PDV in their first 3 years. For the 9172 continuously enrolled children aged 4 to <9 years, 49.3 percent had at least one PDV per year for the first 3 years observed, 15.2 percent had two or more PDVs the first 3 years observed, and 29.3 percent had at least one sealant. For the 23,589 continuously enrolled children aged >9 years, the corresponding figures at 43.6 percent for at least one PDV a year, 11.6 percent for two or more PDVs per year, and 20.4 percent for at least one sealant.

Tables 2, 3, and 4 show raw descriptive statistics and weighted descriptive statistics for enrollees under 4 years, 4≤9 years, and over 9 years, respectively. Results demonstrate that, for almost all cases, propensity score weighing helps attain balance between observed enrollee characteristics using the standardized difference approach. Balance is attained when the standard-

Table 3: Descriptive Statistics for Treatment and Control Groups before and after Propensity Score Weighting: 4≤9 Years

	1+ PDV Per Year						*2+ PDV Per Year*						*At Least 1 Sealant*					
	Raw			*Weighted*			*Raw*			*Weighted*			*Raw*			*Weighted*		
	No Preventive n = 949 (%)	*1+ Preventive n = 4,526 (%)*	*Std. Diff*	*No Preventive n = 949 (%)*	*1+ Preventive n = 4,526 (%)*	*Std. Diff*	*No Preventive n = 949 (%)*	*2+ Preventive n = 1,396 (%)*	*Std. Diff*	*No Preventive n = 949 (%)*	*2+ Preventive n = 1,396 (%)*	*Std. Diff*	*No Sealant n = 6,485 (%)*	*At Least 1 Sealant n = 2,687 (%)*	*Std. Diff*	*No Sealant n = 6,485 (%)*	*At Least 1 Sealant n = 2,687 (%)*	*Std. Diff*
Male	52.9	50.8	4.2	50.7	51.1	0.8	52.9	48.6	8.6	51.0	49.4	3.2	52.8	47.0	11.6	51.0	49.3	3.4
Age*	7.3 (1.2)	7.9 (1.1)	52.1	7.7 (2.4)	7.8 (1.2)	5.3	7.3 (1.2)	8.0 (1.0)	63.4	7.7 (1.6)	7.9 (1.3)	13.4	7.4 (1.1)	8.4 (0.7)	108.5	7.7 (1.3)	7.9 (1.7)	15.5
White	70.5	65.7	10.3	66.5	66.5	0	70.5	64.1	13.7	66.5	65.4	2.3	67.2	61.9	11.1	65.4	62.8	5.4
Black	21.7	26.6	11.5	25.1	25.6	1.1	21.7	26.9	12.1	25.6	25.7	0.2	24.8	30.7	13.2	26.7	28.9	4.9
Other	7.8	7.7	0.4	8.4	7.8	2.2	7.8	9.0	4.3	7.9	9.0	4.0	8.1	7.4	2.6	7.9	8.3	1.5
FPL 100%–150%	40.6	44.4	7.7	41.5	43.6	4.2	40.6	43.6	6.1	41.9	43.2	2.6	41.1	50.2	18.3	43.8	46.1	4.6
FPL 150%–200%	51.1	46.1	10.0	49.2	47.0	4.4	51.1	46.3	9.6	50.0	47.8	4.4	49.1	43.1	12.1	47.5	46.5	2.0
Exempt	1.2	0.8	4.0	1.4	0.8	5.8	1.2	0.8	4.0	1.0	0.8	2.1	0.9	0.7	2.2	0.9	12.0	2.9
Expansion	7.2	8.8	5.9	8.0	9.0	3.6	7.2	9.4	8.0	7.2	8.2	3.8	8.9	6.0	11.1	7.9	6.3	6.2
Urban	63.3	66.4	6.5	64.9	65.8	1.9	63.3	66.0	5.7	62.9	64.2	2.7	66.3	65.7	1.3	66.1	65.7	0.8
Large rural	12.1	12.2	0.3	12.8	12.3	1.5	12.1	12.0	0.3	13.3	12.7	1.8	12.0	11.9	0.3	12.0	11.8	0.6
Small rural	14.2	11.2	9.0	11.7	11.7	0	14.2	11.3	8.7	12.8	12.0	2.4	11.7	13.4	5.1	12.2	13.0	2.4
Isolated	9.0	8.4	2.1	9.2	8.5	2.5	9.0	9.0	0.0	9.6	9.5	0.3	8.5	7.5	3.7	8.2	7.9	1.1
Well-child visits†	2.7 (3.2)	3.1 (3.3)	12.3	2.9 (6.8)	3 (3.6)	1.8	2.7 (3.2)	3.2 (3.3)	15.4	2.9 (4.6)	3.1 (4.0)	4.6	3.3 (3.4)	2.2 (2.8)	35.3	3.0 (3.9)	2.9 (5.6)	2.1

*Mean (SD).
†3-year average per child (SD).

Table 4: Descriptive Statistics for Treatment and Control Groups before and after Propensity Score Weighting: >9 Years

	1+ PDV Per Year						2+ PDV Per Year						At Least 1 Sealant					
	Raw			Weighted			Raw			Weighted			Raw			Weighted		
	No Preventive n = 3,211 (%)	1+ Preventive n = 10,285 (%)	Std. Diff	No Preventive n = 3,211 (%)	1+ Preventive n = 10,285 (%)	Std. Diff	No Preventive n = 3,211 (%)	2+ Preventive n = 2,730 (%)	Std. Diff	No Preventive n = 3,211 (%)	2+ Preventive n = 2,730 (%)	Std. Diff	No Sealant n = 18,772 (%)	At Least 1 Sealant n = 4,817 (%)	Std. Diff	No Sealant n = 18,772 (%)	At Least 1 Sealant n = 4,817 (%)	Std. Diff
Male	56.9	48.8	16.3	49.5	50.6	2.2	56.9	48.4	17.1	52.1	53.9	3.6	50.9	49.8	2.2	50.7	49.5	2.4
Age*	16.1 (2.0)	15.5 (1.9)	31.4	15.5 (4.1)	15.7 (2.2)	3.6	16.1 (2.0)	15.3 (1.9)	41.0	15.5 (4.1)	15.7 (2.2)	3.6	16.0 (2.0)	14.8 (1.6)	66.3	15.7 (2.7)	15.7 (2.9)	0
White	52.0	65.1	26.8	63.7	62.2	3.1	52.0	67.9	35.4	59.6	53.9	1.0	59.8	61.3	3.1	60.1	60.2	0.2
Black	43.1	29.4	28.8	31.2	32.4	2.6	43.1	26.5	32.9	34.8	34.6	0.4	35.2	32.3	6.1	34.6	34.2	0.8
Other	4.9	5.5	2.7	5.1	5.3	0.9	4.9	5.6	3.1	5.6	5.3	1.3	5.0	6.4	6.0	5.3	5.6	1.3
FPL 100–150%	67.5	61.3	13.0	62.1	62.8	1.4	67.5	60.8	14.0	64.9	65.2	0.6	64.1	62.0	4.4	63.6	63.2	0.8
FPL 150–200%	28.3	32.0	8.1	32.8	31.2	3.4	28.3	32.0	8.1	29.9	29.3	1.3	30.4	31.9	3.2	30.7	30.8	0.2
Exempt	1.3	0.7	6.0	0.7	0.8	3.5	1.3	0.4	9.8	0.8	0.6	2.4	1.0	1.0	0	1.0	1.0	0
Expansion	2.9	6.1	15.5	4.5	5.3	3.7	2.9	6.7	17.8	4.4	4.8	1.9	4.6	5.2	2.8	4.7	4.9	0.9
Urban	61.9	62.9	2.1	60.4	62.5	4.3	61.9	60.7	2.5	60.1	60.3	0.4	62.8	64.2	2.9	63.1	63.8	1.5
Large rural	12.5	14.2	5.0	14.5	13.9	1.7	12.5	15.4	8.4	13.9	14.2	0.9	13.5	12.8	2.1	13.3	12.6	2.1
Small rural	13.6	12.3	3.9	15.1	12.7	6.9	13.6	13.3	0.9	14.6	13.7	2.6	12.5	13.1	1.8	12.6	12.9	0.9
Isolated	11.5	9.5	6.5	9.2	10.0	2.7	11.5	9.5	6.5	10.6	11.2	1.9	10.4	8.6	6.1	10.1	9.8	1.0
Well-child visits†	0.9 (1.8)	1.7 (2.6)	37.3	1.9 (5.9)	1.5 (2.8)	6.9	0.9 (1.8)	1.9 (2.7)	43.5	1.9 (5.9)	1.5 (2.8)	6.9	1.3 (2.2)	1.7 (2.6)	16.6	1.4 (3.3)	1.4 (3.4)	0

*Mean (SD).
†3-year average per child (SD).

Table 5: Logistic Regressions

	Birth–4 Years		4–<9 Years						>9 Years					
	At Least 1 Preventive Visit by Age 3 (N = 4,774)		At Least 1 Annual Preventive Visit (N = 5,475)		At Least 2 Annual Preventive Visits (N = 2,345)		At Least 1 Sealant (N = 9,172)		At Least 1 Annual Preventive Visit (N = 13,496)		At Least 2 Annual Preventive Visits (N = 5,941)		At Least 1 Sealant (N = 23,589)	
	β	ME	β	ME	β	ME	β	ME	β	ME	β	ME	β	ME
Any negative outcome (unadjusted)	0.85***	14.0%	1.03***	21.5%	0.97***	17.8%	0.07	1.4%	0.73***	14.2%	0.76***	13.3%	−0.11**	−2.1%
Any negative outcome (adjusted)	0.72***	11.7%	0.98***	18.3%	1.07***	19.1%	0.08	1.7%	0.57***	10.5%	0.71***	13.1%	−0.12*	−2.2%
Any negative outcome costs (unadjusted)	44.43***	–	27.50***	–	15.94	–	−19.44***	–	−0.38	–	0.78	–	−32.63***	–
Any negative outcome costs (adjusted)	32.86*	–	28.99**	–	22.03	–	−15.00**	–	0.74	–	10.18	–	−29.29***	–
Restorative (unadjusted)	0.96***	13.2%	1.04***	19.1%	0.98***	15.6%	0.13*	2.4%	0.82***	14.1%	0.86***	12.9%	−0.09*	−1.6%
Restorative (adjusted)	0.83***	11.1%	0.95***	15.6%	1.09***	16.8%	0.14*	2.7%	0.65***	10.3%	0.83***	13.2%	−0.11*	−1.9%
Restorative costs (unadjusted)	42.59***	–	24.42***	–	14.53*	–	−10.63**	–	1.87	–	0.61	–	−24.4***	–
Restorative costs (adjusted)	37.87***	–	24.80**	–	19.20*	–	−6.43	–	−3.45	–	−0.75	–	−21.3***	–
Emergency (unadjusted)	0.46***	2.9%	0.76***	5.7%	0.72***	4.6%	−0.20*	−1.5%	0.16	0.9%	0.15	0.8%	−0.20**	−1.3%
Emergency (adjusted)	0.31*	1.9%	0.79***	5.0%	0.76**	4.6%	−0.11	−0.9%	0.16	0.8%	0.08	0.5%	−0.12	−0.7%
Emergency costs (unadjusted)	1.83	–	3.08	–	1.41	–	−8.81*	–	−2.25	–	0.17	–	−8.25**	–
Emergency costs (adjusted)	−5.01	–	4.19	–	2.84	–	−8.57**	–	4.20	–	10.93	–	−8.01***	–

Notes. Binary variable for negative outcomes include restorative, nontraumatic dental emergency, endodontic, or periodontic procedures. All outcomes occur in the fourth year of continuous enrollment (costs are sum of expenditures in that year). Modeling annual preventive visits or any sealant over a 3-year period versus no preventive dental/no sealant during that time. Coefficients and risk difference shown for binary outcome modeled with logistic regression; coefficients shown for costs modeled with linear regression, using inverse probability weighting.
$*p < .05$, $**p < .01$, $***p < .001$.

ized difference is less than 10. The only exception is the variable "age" for 4 to <9 years group for two or more PDVs and for sealants, where the standardized difference remains greater than 10.

The logistic regression results in Table 5 indicate that, even after weighting by propensity scores, having at least one PDV by age 3 is associated with a higher probability of restorative visits and emergency visits in year 4. Having a PDV is also associated with more restorative costs in year 4. Emergency dental costs are lower, although the difference is not statistically significant. All of these results are smaller in magnitude in the propensity score-weighted models compared to the unadjusted models.

Similar patterns are seen for the at least one, and at least two, PDVs per year for both the 4≤9 years and the over 9 years groups. Consistent utilization of PDVs is associated with a higher likelihood of restorative and emergency visits, and a higher level of restorative and emergency costs. This pattern persists in the supplementary analysis that considers at least one PDV where fluoride varnish was applied (results are not presented but are available upon request). Only in the case of sealants is there evidence that preventive treatment is associated with reduced probabilities of negative outcomes, and lower levels of costs.

Discussion

Previous observational studies have found that PDVs are not associated with less restorative dental care, and in some cases they have found positive associations between early PDV and more restorative or ED dental visits (Savage et al. 2004; Snyder 2007; Sohn, Lim, and Ismail 2008). The primary challenge to evaluating the effectiveness of PDVs for children has been the problem of selection—namely, that children who utilize PDVs may have unobserved characteristics that also make them more likely to use restorative services. This selection problem makes it challenging to evaluate the 'causal' effect of PDV in terms of improving subsequent dental outcomes. As randomized controlled trials are not feasible in the case of use of preventive services for low-income children, the challenge has been to find empirical methods that can utilize observational data while minimizing selection bias. One previous study has attempted this using the approach of individual fixed effects. Here, we expand the literature by exploring this question using another method to minimize the problem of selection. Using the method of HD-PS, we explore how regular PDVs for at least three consecutive years, or at least one sealant in the past

3 years, is associated with a reduced likelihood of using restorative or ED dental services in the fourth year. For children observed from birth to 4 years of age, the parallel question is whether getting at least one PDV before age 3 is associated with a reduced likelihood of using restorative or ED dental services in the fourth year.

We find evidence that having at least one sealant in the past 3 years is associated with a reduced likelihood of using restorative and ED services as well as corresponding costs. This is concurrent with previous findings on sealants reducing Medicaid costs on dental care (Dasanayake et al. 2003). On the other hand, having regular PDVs for 3 years actually appears to be associated with an increased likelihood of restorative care, ED dental visits, and associated costs in the fourth year. Thus, even after using HD-PS to account for selection, we are unable to find evidence that PDVs per se reduce the need for subsequent restorative services or reduce total program costs.

These results give rise to three conjectures. First, PDVs may actually increase utilization of restorative care because potential problems are identified more quickly, and hence treated more quickly. Thus, there may be unobserved gains from regular PDVs in terms of quality of life, reductions in pain and suffering, and other gains, such as fewer lost school days due to acute dental problems, that are not captured in our model. Second, PDVs may simply be indicative of some unmeasured ability to access dental care, whereby the same enrollees may also have better access to restorative dental care. Third, there may be an element of supplier-induced demand, such that PDVs result in restorative services that may not be essential. However, caution is advised before reaching any definitive conclusions. More research may be called for to understand the links between PDVs and higher utilization of restorative dental services, perhaps with surveys of enrollees and their parents that obtain information on their ability to access dental care, their experience with PDV, and other indicators of subsequent oral health for those who do and do not receive PDV—including experience with dental pain or missed school days due to dental problems.

Several shortcomings are acknowledged. Our approach uses enrollees who have been continuously enrolled in ALL Kids for at least 4 years, and hence the results may not be generalizable to enrollees with shorter durations of enrollment. Our results also cannot be generalized to those with intermittent PDV—for example, those who get PDV in years 1 and 2, but not in year 3. For enrollees who are not in ALL Kids from birth, we have no information about the history of PDVs, restorative service use, or sealants. Also, we focus on outcomes that can be measured via claims data, and—as mentioned previously—we cannot measure outcomes like improved quality of life or fewer missed school days due to dental problems, which may also potentially be impacted by PDV. Moreover, we do not know the extent to which home care instructions are provided during the PDV, or whether parents, guardians, and enrollees have sufficient health literacy to adhere to those instructions. Finally, this is an observational study, and while HD-PS is a powerful empirical tool for reducing the problem of selection bias, some residual confounding may remain. Specifically, HD-PS matches enrollees based on sociodemographic characteristics, well-visits, and an extensive array of claims for other health services. However, this method still may not be able to account specifically for a family or individual history of poor dental health. One prior study suggests that propensity score–based approaches may even exacerbate the imbalance between unmeasured covariates (like poor dental health) between the treatment and control groups (Brooks and Ohsfeldt 2013), though there is not a consensus on this in extant literature (Ali, Groenwold, and Klungel 2014). Thus, future researchers must continue to be aware of the challenges of selection and omitted variable bias, and carefully consider empirical approaches that minimize these problems when evaluating the effectiveness and cost-effectiveness of PDVs.

In conclusion, we do not find evidence that regular PDVs for children enrolled in public insurance programs lead to less restorative or ED dental visits or associated costs. On the other hand, we do find evidence that a specific preventive treatment—dental sealants—is associated with reduced utilization of restorative or ED dental visits. This suggests that oral health practitioners and policy makers may want to put less emphasis on regular biannual PDVs for children, and instead focus more on encouraging appropriate use of specific preventive treatments like sealants. Based on our results, we also suggest more support for approaches like school-based sealant programs as a method for improving oral health of low-income children (Centers for Disease Control and Prevention 2015).

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Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Figure S1: Propensity Score Distribution for At Least One Annual Preventive Dental Visit, Children Enrolled from Birth.

Figure S2: Propensity Score Distribution for At Least One Annual Preventive Dental Visit, Children Aged ≥9 Years.

Figure S3: Propensity Score Distribution for At Least Two Annual Preventive Dental Visit, Children Aged ≥9 Years.

Figure S4: Propensity Score Distribution for At Least One Dental Sealant, Children Aged ≥9 Years.

Figure S5: Propensity Score Distribution for At Least One Annual Preventive Dental Visit, Children Aged ≥9 Years.

Figure S6: Propensity Score Distribution for At Least Two Annual Preventive Dental Visits, Children Aged ≥9 Years.

Figure S7: Propensity Score Distribution for At Least One Dental Sealant, Children Aged ≥9 Years.