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APPENDIX

List of acronyms (in alphabetical order)

Acronym	Definition
1M	Permanent first molar
DALY	Disability adjusted life year
DALYW	Loss in health/well-being due child having toothache
Incidence	Annual probability a child has new first molar cavity
1MAR	Annual probability a sound, unsealed first molar gets a cavity. This value is used to estimate incidence and increment.
Increment	Number of new first molar cavities per year per child
Prob(toothache)	Probability a child with an untreated 1M cavity has a toothache
Prob(untreated)	Annual probability a child has a new 1M cavity that is not filled
SSP	School sealant program

I. METHODS

We estimated the net cost per averted disability-adjusted life year (DALY) over 4 years attributable to a school-based sealant program (SSP) sealing the permanent first molars (1Ms) soon after they erupt. Net cost equals SSP cost per child minus costs for fillings and associated parental time to take his/her child for dental care that were avoided because the child received SSP sealants. The cost per averted DALY per child equals:

$$\frac{\textit{SSP Cost} - \textit{Averted fillings and productivity losses}}{\textit{Averted DALYS due to reduced toothaches attributable to SSP}}$$

Where:

- *Averted fillings and productivity losses* equals SSP effectiveness * (1- prob(untreated)) * [(increment * filling cost) + (incidence * productivity losses)]
- *Averted DALYS equals SSP effectiveness * incidence * prob(untreated) * prob(toothache) * DALYW*

In the following sections we describe the calculations to estimate how cavity and increment were estimated and how the other parameter values were derived.

I.A. Estimating Cavity Outcomes

Estimating Permanent 1st Molar Annual Attack Rate

We used de-identified data for children, aged 6 to 10 years, screened by SSPs in 14 states[1] between 2013 and 2014. Almost all programs served schools where greater than 50% of the students participated in the free/reduced meal program (eligibility based on family income ≤185% federal poverty level). Prior to placing sealants, SSP dentists or hygienists visually assessed each child's teeth. Increment was recorded during the assessment prior to sealant placement. We used data on increment for 36,753 children, aged 7 to 11 years, who were also assessed as having no sealants. To calculate the permanent first molar attack rate (1MAR), we used a published methodology (1). We first estimated the cumulative probability a 1M developed a cavity by summing increment by year of age and then dividing this sum by the number of 1M (number of children*4). We subtracted the cumulative probability a 1M developed a cavity from 1 to estimate the cumulative probability a 1M did not develop a cavity, i.e., sound 1M. Assuming a constant attack rate and that 1M erupt at age 6 (2) the annual probability a 1M is sound can be obtained by taking the nth root of the cumulative probability of a sound 1M where n equals the age of the child minus 6. This annual probability a 1M is sound was subtracted from 1 to obtain the 1MAR for each age group. The weighted average 1MAR was 0.078 (Exhibit A1).

[1] Connecticut, Georgia, Iowa, Kansas, Louisiana, Maryland, Minnesota, Mississippi, New York, North Dakota, Rhode Island, South Carolina, West Virginia, and Wisconsin.

Calculating 1M Cavity Incidence and Increment

A child has 4 first molars (1M), each of which could be sound (S)in the first year after eruption with probability 0.922 or have a cavity (C) with probability 0.078. Thus there are 16 possible events (Exhibit A2A) – 1 with no first molar cavities, 4 with 1 first molar cavity, 6 with 2 first molar cavities, 4 with 3 first molar cavities, and 1 with 4 first molar cavities. In time period 1, the probability of no first molar cavities is 0.922^4, 1 first molar cavity is $0.922^3*0.0728$, 2 first molar cavities is $0.922^2*0.078^2$, 3 first molar cavities is $0.922*0.078^3$, and 4 first molar cavities is 0.078^4. Multiplying these probabilities by the corresponding number of events provides us with the probabilities a child can have each of the following outcomes -- 0, 1, 2, 3, and 4 1M cavities. Multiplying the probability of each 1M cavity outcome by the number of cavities associated with that outcome provides us with the cumulative increment per child (Exhibit A2B). We can calculate the probabilities for year 2 in the same manner (Exhibit A2B) assuming the probability a 1M remains sound for 2 years is 0.922^2. Incidence, the probability a child develops at least one 1M cavity, equals 1 minus the probability that all 1Ms remain sound.

The marginal or annual probabilities are defined by the difference in in the cumulative probabilities (Exhibit A2C) for years n+1 and year n. For example, the marginal probability of two 1M cavities in year 3 (0.075) equals the 3-year cumulative probability of two 1M cavities

(0.172) minus the 2-year cumulative probability of two 1M cavities (0.097). Finally, the 1M caries increment in year n equals the difference in the cumulative first molar caries increment from year n-1 to year n. Marginal incidence can be estimated in the same manner.

Assumptions

Literature supporting the assumptions used to model caries increment and incidence are provided below:

1. All cavities in the permanent teeth occur in the pits and fissures of 1Ms. This is consistent with findings that about 90% of caries in the permanent teeth of children occur in the pits and fissures of posterior teeth (3) and that the only permanent posterior teeth likely to be erupted before age 10 are 1Ms (2).
2. All 1Ms erupt at age 6 (2).
3. The annual probability that a sound 1M develops a cavity is constant (1).
4. Sealants protect teeth against cavities for 4 years (4). In the most recent Cochrane review of dental sealants that included studies placing sealants in schools and dental offices, a few studies had follow-up periods exceeding 4 years, but the majority stopped at 4 years or less (5). The Cochrane review only performed meta-analyses on studies with follow-up times of 4.5 years or less. The number of

studies that examined sealant effectiveness for follow-up times of 1, 2, 3, and 4 years were 6, 6, 7, and 5 studies, respectively, whereas for follow-up times of 5, 6, 7, and 9 years there was only one study per period[1].

5. All four 1Ms are sealed by the SSP. This is consistent with studies estimating sealant loss rates (6, 7) and national data indicating that the average number of sealed 1Ms among children, age 6 to 11 years, with sealants is 3.23 (8).
6. All cavities occur at the beginning of the year. At this point 1M cavities can be filled or remain untreated for the duration of the year. This assumption was made for model tractability.
7. A child who develops 1M cavities and has them filled will visit the dentist once regardless of number of 1M cavities.
8. All untreated 1M cavities that are untreated in year i are filled year i+1.

I.B. Other Parameters

Probability new cavity remains untreated prob(untreated). We used published data from the 2007 National Health Interview Survey (NHIS) Supplement on parental report of whether their child had received dental treatment for a dental problem (9). This article classified dental problems as urgent (cavity, toothache, broken/missing tooth or

[1] See Comparison 1 in Data and Analysis Section.

restoration and bleeding gums) or non-urgent (stained, crooked, or loose teeth; dry mouth, jaw pain, mouth sores, and bad breath). We subtracted estimated probability of visiting the dentist among low-income (<100% federal poverty level) children for a reported urgent problem, 0.53 (standard error = 0.03) from 1 to estimate prob(untreated). We used dental visit for an urgent problem because most of these problems would be cavity-related.

School-sealant effectiveness. We estimated sealant effectiveness at 1, 2, 3, and 4 years after placement assuming sealant effectiveness decreased each year after placement. We first converted odds ratios reported in the 2013 Cochrane review (5) to relative risk ratios using the following equation: RR=OR/(1-1MAR*(1+OR)) where OR represents odds ratio and 1MAR equals 0.078. These relative risk ratios were adjusted upward (multiplied by 3.2) such that the overall 4-year effectiveness would be 50%, the estimate in the Task Force's effectiveness systematic review (4). The percentage reduction in incidence and increment due to sealants was 68.5%, 57.9%, 40.1% and 25.8% at 1, 2, 3, and 4-year follow-up.

We also estimated cost-effectiveness assuming sealants were effective up to 9 years. We used effectiveness estimates (relative risk or odds ratio converted to relative risk) for the 4 studies comparing sealant to no sealant with follow-up times of 5, 6, 7, and 9 years in the same Cochrane review. Effectiveness for these studies ranged from

55% to 65% with a mean value of 61%. For this analysis, we assumed a constant effectiveness of 61%.

Reduction in caries increment will depend on effectiveness and number of teeth sealed. For the base case we assumed that children received sealants on 4 first molars and in a sensitivity analysis set the number of sealed teeth to 3.

Probability child with untreated cavity has toothache. We used published estimates from national survey data on the ratio of percentage of 6 to 17-years-olds in 2007 with a reported toothache within the last six months (12.0% (10)) to the percentage of 5 to 19-year-olds in 2005 to 2008 with at least one untreated cavity (16.6% (11)) to estimate the probability that a child with at least 1 untreated cavity would experience pain, 0.721.

Loss in health/well-being due to toothache. To measure the loss in health/well-being resulting from having a toothache for one year, we used DALY data from the Global Burden of Disease. Because cavities rarely result in death, the Global Burden of Disease only included the effect of morbidity (toothache due to untreated cavities) on quality of life (12). This value was estimated to be 0.012.

SSP cost. We used the findings from the systematic review of economic analyses conducted for the Task Force (4). This review located four

studies conducted in the US with primary data for the cost of all resources used by nine SSPs ((13-16); one included study (14) reported cost estimates for six SSPs in five states (Exhibit A4). In one study (16), the reported time of 56 minutes to deliver 3.1 sealants to one child was double the 26 minutes reported on the Association of State and Territorial Dental Directors School Sealant program Best Practices website (17). Another study (15) reported sealing 11 teeth per child, which was more than twice the value (4 teeth) that SSPs typically target (all 1M in lower grades and 2nd molars in higher grades; (17)). Mean/median SSP cost per child was $63.33/$75.80, excluding these studies with outlier values and $80.33 for all studies (Exhibit A4). For the base-case analysis, we estimated SSP cost excluding studies with outlier values and then used the mean for all studies in a sensitivity analysis.

Cost per Filling. To estimate the costs of resources used to fill a 1M cavity, we used information from the American Dental Association surveys on the average fee for pediatric dentists (18) and relative frequency of placing one and two surface fillings (19) applied on the permanent molars (Exhibit A5). Dental sealants can prevent cavities on the occlusal and buccal surfaces of 1M in the lower arch and occlusal and lingual surfaces on the upper arch. Fillings placed on the molars (posterior teeth) can be one and two-surface amalgam or composite. We estimated the average cost to fill a 1M to be $173.98[1]

[1] Fees from 2013 were converted to 2014$.

(Exhibit A5). Existing guidance recommends using average private reimbursements instead of public insurance reimbursements (20). To be conservative we searched for information on the percentage of private fees that are reimbursed by insurance companies based on the reasoning that insurance companies may be able to negotiate reimbursements to that which would prevail if dental markets were perfectly competitive. We used data from the Fair Health calculator (19) to estimate the percent of total charges that insurance companies reimburse (the remaining costs being out of pocket for the patient). We randomly sampled the total cost and portion that private insurance would reimburse for 50 US zip codes, 25 of which were from cities in the top 40 in population, for amalgams and posterior composite fillings. Regardless of dental procedure, information from this website indicates that insurance companies reimbursed dentists for 80% of their charges [95%CI: 0.77, 0.83]. We therefore estimated the cost of resources to place a filling to be $139.18 (=0.80*$173.98). In a sensitivity analysis we calculated cost-effectiveness using the most conservative estimate of resources to fill a cavity – assuming only single-surface fillings and using Medicaid fees for amalgam and composite fillings from the 14 states that provided us with their SSP screening data. This value was $64.17.

Productivity losses. We assumed that any child with new 1M caries would visit the dentist only once to receive necessary fillings

regardless of the number of 1M fillings. Thus productivity losses would be multiplied by incidence not increment. We estimated the value of lost productivity associated with a parent taking his/her child to the dentist for a filling from the estimated time (1.5 hours) from national survey data on the average time for dental visit (includes travel and wait time;(21)) and the hourly value of household services, $14.23(22). The total cost of lost productivity from a parent taking their child to a dentist for a filling was $21.34. We estimate net-costs (numerator of cost-effectiveness ratio) without productivity losses in a sensitivity analysis.

I.C. Analysis

We estimated the cost effectiveness of SSPs using base-case parameters (Exhibit A6) and with the following parameters:

1. Children served by SSP only have 3 1M eligible for sealants, i.e., one 1M already has a cavity or has not yet erupted.
2. Higher SSP cost that included studies with outlier values.
3. Cost of resources used to restore 1M cavity is the average fee for single-surface fillings paid by Medicaid in the 14 states.
4. There are no productivity losses associated with a dental visit.

We also examined the relative impact of each parameter on our findings when each parameter value varied from 50% to 150% of its

base-case value. We further examined the effect of allowing the first molar cavity attack rate and SSP cost to vary simultaneously.

We performed a probabilistic sensitivity analysis through the use of Monte Carlo simulation. In this analysis, we allowed all parameters to vary simultaneously (Exhibit A6). The distributions for each random variable were determined using the Kolmogorov-Smirnov test. The distribution assigned to each parameter is shown in Exhibit A6.

The probabilistic sensitivity analysis was conducted for a population of 1,000 children, using 1,000 replications in the analysis. The mean and standard deviations were determined for net SSP cost, averted years living with a toothache per child, averted fillings, and cost per averted DALY.

We used two cost-effectiveness thresholds -- cost savings and cost per averted DALYs being less than $54,639, i.e., 2014 US gross domestic product (GDP) per capita. Although the latter threshold has been criticized, we include it because of its common usage (19).

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Exhibit A1: Annual 1M attack rate for children with no sealants at baseline screening prior to sealant placement by age: SSPs in 14 states[a], 2013-2014

AGE	Number screened	Mean	SE	Median
7	15676	0.089	0.009	0.089
8	11450	0.073	0.007	0.069
9	5318	0.067	0.007	0.070
10	4310	0.065	0.008	0.061
Weighted across age groups	36753	0.078	0.007	0.077

[a]Estimated from data collected at baseline screening by school-based sealant programs in Connecticut, Georgia, Iowa, Kansas, Louisiana, Maryland, Minnesota, Mississippi, New York, North Dakota, Rhode Island, South Carolina, West Virginia, and Wisconsin.

Exhibit A2A: Number of events for permanent first molar (1M) cavity outcome per child (S=sound; C=cavity).

Number of 1Ms with cavities				
0	**1**	**2**	**3**	**4**
SSSS	SCSS	CCSS	CCCS	CCCC
	CSSS	SCSC	SCCC	
	SSSC	CSSC	CSCC	
	SSCS	SCCS	CCSC	
		CSCS		
		SSCC		

Exhibit A2B: Cumulative probabilities per child not receiving sealants having 0-4 1M cavities and cumulative increment for children receiving no sealants by year

	Probabilities for number of 1Ms with cavities					Increment
Year	0	1	2	3	4	
1	0.723	0.245	0.031	0.002	0.000	0.312
2	0.522	0.368	0.097	0.011	0.001	0.598
3	0.377	0.416	0.172	0.032	0.002	0.856
4	0.273	0.419	0.241	0.062	0.006	1.086

Exhibit A2C: Annual probabilities per child not receiving sealants having 0-4 1M cavities and annual caries increment by year

	Number of DF1M					Increment
Year	0	1	2	3	4	
1	0.723	0.245	0.031	0.002	0.000	0.312
2	0.522	0.124	0.066	0.010	0.000	0.286
3	0.377	0.048	0.075	0.020	0.002	0.259
4	0.273	0.002	0.069	0.030	0.004	0.230
Over 4 years		**0.419**	**0.241**	**0.062**	**0.006**	**1.086**

Exhibit A3: Per Child caries outcomes without sealants by year

Year	First molar caries Increment	First molar untreated Increment	First molar filling Increment	Incidence
1	0.312	0.198	0.114	0.277
2	0.286	0.182	0.302	0.200
3	0.259	0.164	0.276	0.145
4	0.230	0.146	0.248	0.105
TOTAL	**1.086**		**0.940**	**0.727**

Exhibit A4: School Sealant Program cost per child by resource category

STUDY	Labor	Equipment	Supplies	Travel	Other	Total
Garcia 1	$32.87	$1.03	$6.17	$1.77	NR	$41.84
Garcia 2	$35.30	$2.06	$5.27	$3.33	NR	$45.97
Garcia 3	$62.59	$3.00	$9.59	$0.41	$0.19	$75.80
Garcia 4	$66.62	$3.35	$5.82	$0.58	NR	$76.37
Garcia 5	$63.31	$1.67	$8.60	$1.89	$1.11	$76.58
Garcia 6	$77.26	$4.16	$7.73	$0.56	$1.07	$90.77
Calderone	$23.51	$3.89	$5.35	$3.27	NR	$36.00
Klein	NR	NR	NR	NR	NR	$116.44
Werner	$149.52	$1.27	$12.37	NR	NR	$163.16
Median	**$62.95**	**$2.53**	**$6.95**	**$1.77**	**$1.07**	**$76.37**
Mean	**$63.87**	**$2.55**	**$7.61**	**$1.69**	**$0.79**	**$80.33**
Without Werner and Klein						
Median	**$62.59**	**$3.00**	**$6.17**	**$1.77**	**$1.07**	**$75.80**
Mean	**$51.64**	**$2.74**	**$6.93**	**$1.69**	**$0.79**	**$63.33**

Exhibit A5 Cost of posterior fillings

Filling type	Fee (2014 US$)	% of fillings	Weighted value
Amalgam – 1 surface		15%	
Amalgam – 2 surface		24%	
Composite – 1 surface		28%	
Composite – 2 surface		32%	
TOTAL			

*We reduced total weighted value by 20% and used this value,

Exhibit A6: Parameters Used in Analysis

Parameter	Base value (SD)	Distribution in Probabilistic Sn analysis	Data Source
First molar cavity attack rate	0.078 (0.026)	Uniform Distribution	SSP in 14 states
Probability new cavity remains untreated	0.470 (0.023)	Uniform Distribution	Published analysis of National Health Interview Survey (9)
School-sealant effectiveness 1-year	68.5% (11.3%)	Normal Distribution	Community Preventive Services Task Force Review (4); (This review included Cochrane review (5) findings)
School-sealant effectiveness 2-year	57.9% (17.8%)	Normal Distribution	(4, 5)
School-sealant effectiveness 3-year	40.1% (30.8%)	Normal Distribution	(4, 5)
School-sealant effectiveness 4-year	25.8% (16.2%)	Normal Distribution	(4, 5)
Probability child with untreated cavity has toothache	0.721 (0.113)	Uniform Distribution	Published data from National Survey of Children's Health on toothache prevalence and examination data on untreated tooth decay from National Health and Nutrition Examination Survey (10, 11)
Loss in health/well-being due to toothache	0.012	Constant	Global Burden of Disease DALY weight for untreated tooth decay causing pain (12)
School-based sealant program resource costs	$63.33 ($21.46)	Normal Distribution	Community Preventive Services Task Force Economic Review of SSP (4)
Cost per filling	$139.18 ($23.99)	Uniform Distribution	American Dental Association survey on frequency of dental services rendered (19) and cost of service (18)
Productivity losses	$21.34 ($3.33)	Normal Distribution	American Dental Association Survey Data on average time for dental visit (21) and productivity losses for household work (22)