Cost-Effectiveness Analysis of Dental Sealants versus Fluoride Varnish in a School-Based Setting

Matthew Neidell^a Barbara Shearer^b Ira B. Lamster^a

^aDepartment of Health Policy and Management, Mailman School of Public Health, Columbia University, and

^bColgate Oral Pharmaceuticals, New York, N.Y., USA

Key Words

Cost-effectiveness · Dental sealants · Fluoride varnish

Abstract

While sealants are more effective than fluoride varnish in reducing the development of new carious lesions on occlusal surfaces, and a course of treatment requires fewer clinical visits, they are more expensive per application. This analysis assessed which treatment is more cost-effective. We estimate the costs of sealants and fluoride varnish over a 4-year period in a school-based setting, and compare this to existing estimates of the relative benefits in terms of caries reduction to calculate the relative cost-effectiveness of these two preventive treatments. In our base case scenario, varnish is more cost-effective in preventing caries. Allowing for caries benefits to nonocclusal surfaces further improves the cost-effectiveness of varnish. Although we found that varnish is more cost-effective, the results are context specific. Sealants become equally cost-effective if a dental hygienist applies the sealants instead of a dentist, while varnish becomes increasingly cost-effective when making comparisons outside of a traditional dental clinic setting.

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Dental caries is the most common chronic disease of childhood, and is also the most prevalent disorder in the 2010 Global Burden of Disease Study (prevalence of 35%) [Marcenes et al., 2013]. Important risk factors for dental caries in children include variables associated with income and race/ethnicity [Tinanoff, 1995; Reisine and Psoter, 2001]. More than half of young children (up to age 5) from families living below the federal poverty line demonstrated dental caries versus only about one-third of children in families earning 200% above the poverty line [Moyer, 2014].

One of the major health care challenges in the prevention and treatment of dental caries is access to an oral health care system, which includes both a defined approach to prevention and providers to treat established lesions [Sen et al., 2013]. Dental caries is a preventable disease, and a recognized community-based preventive approach is water fluoridation [Parnell et al., 2009]. Posteruption strategies for preventing dental caries include dental sealants and fluoride varnish [Burt, 1998; Hiiri et al., 2010].

The efficacy of pit and fissure sealants and fluoride varnish has been investigated [Kallestal et al., 2003; Hiiri et al., 2010]. Studies comparing the two treatments have generally found that sealants are more effective in reducing the development of new carious lesions on occlusal surfaces [Hiiri et al., 2010]. Such comparisons,

however, do not factor in the economic costs associated with each treatment [Chestnutt et al., 2012]. From a public health perspective, limited resources need to be utilized efficiently to realize the largest health care gain. Compared to varnish, sealants are more expensive per application and require a more sophisticated infrastructure, though fewer applications are needed over time, making it unclear a priori which treatment will be more cost-effective.

Given a fixed budget, which treatment results in a greater reduction in caries? For example, if an organization is awarded a fixed amount to develop an oral health prevention program for children, how can they best allocate these resources to obtain the greatest reduction in caries? The scenario is a school-based clinic or other nontraditional setting where children receive either sealants, with the possibility of reapplication, or a fluoride varnish once every 6 months. We estimate the costs over a 4-year period, and compare this to existing estimates of the relative benefits in terms of caries reduction to calculate the relative cost-effectiveness of these two preventive treatments.

Materials and Methods

The goal of this cost-effectiveness analysis was to estimate the average cost-effectiveness ratio (ACER), which is the amount of dollars spent for each lesion that is prevented. We tested whether the difference in the estimated ACERs for sealants versus varnish was statistically significant by computing a t-statistic. We directly compared each treatment by taking the ACER of the sealants and measuring it against the varnish ACER. A value greater than 1 indicated that varnish was more cost-effective than sealants. Correspondingly, a value less than 1 indicated that sealants were more cost-effective.

In order to obtain these estimates, both the oral health benefits and health care costs of varnish and sealants must be known. We identified Bravo et al. [2005] as providing the most relevant estimates for measuring the oral health benefits since their study was performed in a school-based dental clinic. This was a randomized clinical trial comparing sealants and varnish with an untreated control group of 6- to 8-year-old schoolchildren. The children in the sealant group were treated at the beginning of the trial, with reapplication performed as required until 3 years after the initial application. Children in the varnish group received treatment at the beginning of the trial and every 6 months thereafter through 3.5 years. After 4 years, the percent reduction in occlusal caries was 76.3% (95% confidence interval, CI: 60.8–91.8) for sealants compared to no treatment and 43.9% (95% CI: 23.7–64.1) for varnish compared to no treatment, suggesting that sealants were more effective in caries reduction.

It is important to note that Bravo et al. [2005], as well as other studies comparing sealants to varnish [Hiiri et al., 2010], only examined caries reduction for occlusal surfaces. Since varnish, unlike sealants, is a full-mouth treatment, it provides additional benefits to nonocclusal surfaces [Modeer et al., 1984; Bravo et al., 1997]. To

Table 1. Details and costs of sealant and varnish applications

	Sealants	Varnish
Labor costs per patient, USD	75.00	2.50
Time needed to apply treatment, min	30	5
Applicator training level	D, DH	SA
Combined wage per hour, USD	150.00	30.00
Reapplication rate, USD	0.10	–
Material costs per patient, USD	19.56	4.20
Equipment costs per patient, USD	0.21	0.01
Curing light, USD	625.00	–
Patients treated before replacement, n	10,000	–
Bulb replacement, USD	50.00	–
Patients treated before replacement, n	1,000	–
Dental chair, USD	985.00	50.00
Patients treated before replacement, n	10,000	10,000
Training costs per patient, USD	–	0.21
SA hours, n		7
Patients treated per aide, n		1,000
Treatment duration, months	42	6
Discount rate, %	6	6
Total treatment costs per 3.5 years, USD	104.25	44.96

D = Dentist; DH = dental hygienist; SA = school aide.

account for this, a sensitivity analysis was performed by scaling the percent caries reduction for varnish to allow for these potential benefits. In the absence of published estimates, we used a range of estimates from 0.05 to 0.20, with a value of 0.05 meaning that for every 20-unit reduction in occlusal caries there was a 1-unit reduction in caries on nonocclusal (smooth) surfaces.

Since cost data were not published in the study by Bravo et al. [2005], we calculated the average costs of the two treatments, defining the treatments analogously to the trial. We defined all of the inputs (materials, equipment, and labor) necessary for performing the treatments on a per-child basis according to standard practice, and then defined the parameters for these inputs using published figures and data from a dental school clinic. The spreadsheet used for all calculations is available at www.columbia.edu/~mn2191/sealants_varnish.xls.

Results

Table 1 provides the inputs and associated costs. For sealants, the materials included personal protective equipment, etching gel, primer, sealants, and tips, and were estimated at a cost of USD 19.56 per child. Equipment included a curing light (light-cured and not auto-polymerizing sealants were considered), replacement bulbs, and a portable dental chair. The curing light was estimated at USD 625 and assumed to last for 10,000 patients before needing replacement. A replacement bulb with a cost of

Table 2. Cost-effectiveness estimates of sealants versus varnish, assuming a 10% sealant reapplication rate

	Nonocclusal benefits, %	Caries reduction, %	SE	ACER, USD	95% CI, USD	t-statistic	Ratio
Sealants	0	0.763	0.079	136.63	113.58–171.42		
Varnish	0	0.439	0.103	102.41	70.15–189.60	1.69	1.33
	5	0.461	0.108	97.53	66.81–180.57	1.99	1.40
	10	0.483	0.113	93.10	63.77–172.37	2.29	1.47
	15	0.505	0.118	89.05	61.00–164.87	2.57	1.53
	20	0.527	0.124	85.34	58.46–158	2.84	1.60

Caries reduction is based on the study by Bravo et al. [2005]. SE: the standard error of caries reduction. t-statistic: the t-statistic was computed for the difference in ACER between the sealant estimate and each varnish estimate. Ratio: the ratio of the ACER between the sealant estimate and each varnish estimate.

Table 3. Cost-effectiveness estimates of sealants versus varnish, assuming a 40% sealant reapplication rate

	Nonocclusal benefits, %	Caries reduction, %	SE	ACER, USD	95% CI, USD	t-statistic	Ratio
Sealants	0	0.763	0.079	173.89	144.56–218.17		
Varnish	0	0.439	0.103	102.41	70.15–189.6	3.21	1.70
	5	0.461	0.108	97.53	66.81–180.57	3.52	1.78
	10	0.483	0.113	93.10	63.77–172.37	3.82	1.87
	15	0.505	0.118	89.05	61–164.87	4.10	1.95
	20	0.527	0.124	85.34	58.46–158	4.36	2.04

See footnote in table 2 for explanations.

USD 50 was needed after each 1,000 patients. A portable dental chair, also assumed to last for 10,000 patients before replacement, was valued at USD 985. Labor involved a time of 30 min from a dentist/dental hygienist and dental assistant to apply sealants to 4 occlusal surfaces, with a combined hourly wage of USD 150. One initial treatment was assumed, though we also allowed for the possibility of sealant reapplication, assuming a failure rate of 10%. We also assessed sensitivity to this assumption by allowing a failure rate of 40%. Although energy costs for the curing light were initially calculated, they were negligible and hence excluded. Side effects were assumed to be nonexistent for both preventive treatments.

For varnish, materials included limited personal protective equipment, a tray, the varnish, and a brush, which were approximated at USD 4.20. Equipment included a basic folding chair, valued at USD 50 and assumed to last for 10,000 patients before needing replacement. Labor consisted of a school health aid or nurse to apply the var-

nish – estimated at 5 min per application at an hourly wage of USD 30. Labor also consisted of a program to train the health aid or nurse to apply the varnish – estimated at 7 h and assuming the aid or nurse will treat 1,000 patients. Since varnish was reapplied every 6 months, we computed the present value of all costs by applying a 6% discount rate, which is an interest rate used to convert future values into the present.

Over a 4-year period, sealants cost USD 104.25 per child. Although applied more often, the present value of varnish costs were USD 44.96 per child. In terms of cost-effectiveness, as shown in table 2, the ACER for sealants was USD 137 (95% CI: 114–171), indicating a cost of USD 137 for each reduction in caries, and the ACER for varnish was USD 102 (95% CI: 70–190). The ACER ratio of 1.33 indicates that varnish is more cost-effective in reducing caries, though the t-statistic of 1.68 means that the difference is not statistically significant. If benefits to nonocclusal surfaces are considered, the ratio of ACERs rises to 1.40

with a 5% reduction and 1.601 with a 20% reduction, and these differences are statistically significant. Table 3 shows the same set of estimates but assuming a sealant failure rate of 40%. The ratio of ACERs rises to 1.70 with no benefits to nonocclusal surfaces and increases to 2.04 with a 20% benefit to nonocclusal surfaces. All of the estimated differences in ACERs are statistically significant.

Discussion

Prevention of dental caries in children is important in establishing oral health over the life course. The most frequently employed professional approaches for caries prevention include fluoride varnish and dental sealants.

The efficacy of fluoride varnish in preventing dental caries has been established [Weyant et al., 2013]. A Cochrane review indicated that the reduction in dental caries versus a placebo control, or no treatment, was 43% for the permanent dentition and 37% for the primary dentition [Marinho et al., 2013]. The frequency of applications was twice per year, while some studies administered the varnish 4 times per year. The US Preventive Services Task Force recommends that fluoride varnish be applied to primary teeth, beginning with the eruption of the first primary tooth. As such, the age at which fluoride varnish is utilized professionally is earlier than the age when dental sealants are applied (eruption of the permanent first molar teeth) [Moyer, 2014].

In the context of a community-based oral health preventative program, fluoride varnish does not require a professional dental infrastructure (dental chair with illumination, fluid evacuation to maintain a dry field). Health care providers with minimal training can apply varnish.

Dental sealants are indicated for use in permanent premolar and molar teeth, with a greater emphasis on first molars. Sealants have also been used to seal occlusal surfaces of primary molar teeth, and a cost-effectiveness analysis of this treatment has been shown to reduce subsequent dental costs [Chi et al., 2014]. Furthermore, dental sealants provide protection against the development of dental caries when applied to pits and fissures, though there is no evidence that sealants have a beneficial indirect effect on caries development elsewhere in the dentition. In addition, while the clinical efficacy of occlusal sealants has also been established, the reduction in occlusal caries with dental sealants is dependent in part on the retention of the sealants [Oulis and Berdouses, 2009]. While conceptually sealants are applied once, loss of the sealant requires reapplication. Sealant retention on molar

teeth has been reported to be at least 90% during the first 2 years, but decreases to about 60% by 5 years [Bendinskaite et al., 2010]. Dental sealants have also been evaluated for their efficacy on smooth surfaces, specifically the prevention of smooth-surface white spot lesions associated with orthodontic bonded appliances. This therapy did not prove effective [O'Reilly et al., 2013].

A review of the effectiveness of pit and fissure sealants versus fluoride varnish for the prevention of occlusal caries concluded that sealants were more effective than varnish in preventing the development of new occlusal lesions [Hiiri et al., 2010]. An individual with traditional dental insurance that covers both treatments would probably choose sealants as a preferred method for caries prevention. However, due to limited available data, no conclusions could be drawn to allow a recommendation for the preferred preventive strategy on a public health basis where costs of the two techniques are an important consideration.

Although sealants are more effective than varnish at reducing caries, they cost more per patient. This higher cost largely stems from the differences in labor: a time of 30 min from a dentist and dental assistant per sealant application compared to 5 min from a school health aide per varnish application.

In a public health setting where the goal is a reduction in the caries burden for a community or school body, and with a fixed budget, then the effectiveness of sealants is lessened because of the greater costs required to deliver the service. A community-based preventive oral health care program for children would seek to yield the greatest reduction in caries incidence for a net amount of funds expended. The current study provides a cost-effectiveness analysis to compare two community-based caries prevention programs. Taking costs into account, our analyses suggest that using varnish is more cost-efficient than sealants, particularly as benefits accrue to nonocclusal surfaces, and the sealant reapplication rate rises.

If, however, a dental hygienist or mid-level dental provider applies the sealants, this reduces the cost of sealants relative to varnish. For example, assuming a hygienist applies the sealants and a dental assistant is present, this yields a combined wage rate of USD 100 per hour instead of USD 150. In this case, the ratio of ACERs falls to 0.98 without nonocclusal surface benefits from varnish and 1.18 with 20% nonocclusal surface benefits (all estimates not statistically significant), suggesting the two are equally cost-effective.

The availability of a functional dental operatory that would provide the conditions needed for the application

of dental sealants is one critical variable in this analysis. Isolation, oral fluid evacuation, illumination, and use of a curing light are required, and the required infrastructure may not be available in schools located in communities associated with high caries prevalence. Without this infrastructure, the appeal of varnish is enhanced. Since the application of varnish requires very little infrastructure, it can be more readily applied in nontraditional settings. Therefore, our estimates would be more in favor of varnish being cost-effective if we were to make this comparison outside of a setting with a dental clinic, such as a remote setting, a health fair, or a school without a dental operatory.

In summary, our estimates suggest that although sealants provide greater caries reduction, the expertise needed for application imposes a much higher cost such that varnish appears more cost-effective. This suggests that varnish will yield a greater reduction in caries for a fixed budget in the school-based setting examined here, though allowing for different contexts will have important implications for this conclusion.

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Author Contributions

M.N. performed the analysis and wrote the manuscript. B.S. conceived the study. I.B.L. contributed to the analysis and wrote the manuscript.

Disclosure Statement

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