Preventive Oral Health Interventions:  
A Review of the Evidence

The Washington State Legislature directed the Washington State Institute for Public Policy (WSIPP) to “calculate the return on investment to taxpayers from evidence-based prevention and intervention programs and policies.” Additionally, WSIPP’s Board of Directors authorized WSIPP to work on a joint project of the MacArthur Foundation and the Pew Charitable Trusts to extend WSIPP’s benefit-cost analysis to certain public health, health care, and other topics.

As part of the Pew-MacArthur Results First Initiative, preventive dental care was identified as an important public health issue, with potential net savings to states. In Washington State, dental care represents significant expenditures in Medicaid, public employees’ benefits, and in agencies such as the Department of Corrections. The goal of this study was to identify evidence-based ways to prevent or reduce some of these costs.

This report presents a summary of the evidence of the effectiveness of three oral health interventions.

Summary

WSIPP’s Board of Directors authorized WSIPP to work on a joint project of the MacArthur Foundation and the Pew Charitable Trusts to extend WSIPP’s benefit-cost analysis to certain public health, health care, and other topics.

The Pew-MacArthur Results First Initiative identified preventive dental care as an important public health issue that may have long-term implications in Medicaid and other health care expenses.

WSIPP conducted literature reviews on five dental topics: fluoride varnish, sealants, community water fluoridation, mid-level dental providers, and preventive dental visits. We found sufficient rigorous evaluations to analyze the effect of three of the five oral health interventions on tooth decay: fluoride varnish, sealants, and community water fluoridation.

We found that all three interventions decrease tooth decay in youth, although the analysis of community water fluoridation was based on only two rigorous studies. These studies did not measure other outcomes of interest, such as dental and medical services use, bone development, and fluorosis.

We also did not find sufficient research quantifying the link between youth tooth decay and long-term health and economic outcomes. Therefore, we were not able to complete a benefit-cost analysis of these interventions at this time.


1 Laws of 2009, Ch. 564, § 610 (4), ESHB 1244.
I. Oral Health in Washington

Tooth decay is one of the most common diseases among children. More than half the children in Washington have experienced tooth decay by third grade (Exhibit 1).\(^2\) Children from disadvantaged backgrounds and those from racial and ethnic minority groups experience more tooth decay than their peers.

Tooth decay continues to impact individuals throughout their lifetime. For example, tooth decay is a common reason for tooth extraction.\(^3\) In Washington, 39% of people at least 18 years of age had at least one tooth extracted and 11% of adults at least 65 years of age have had all of their natural teeth extracted.\(^4\)

Washington State funds dental care for some people through Medicaid, the Public Employees Benefit Board, and agencies such as the Department of Corrections. Exhibit 2 presents information about each of these state resources for dental care.

Additionally, the Washington State Department of Health promotes oral health by licensing dental professionals, disseminating oral health education and resource materials, collecting surveillance data, and monitoring the most common dental public health intervention—water fluoridation.

Local governments, however, make the decision of whether or not to add fluoride to the public water supply. In 2012, 63% of residents using community water systems in Washington received fluoridated water.\(^5\)

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\(^{3}\) Other reasons for tooth extraction include trauma and periodontal (gum) disease.


<table>
<thead>
<tr>
<th>Provided by</th>
<th>Eligible population</th>
<th>Number of individuals who received services</th>
<th>Cost of dental services</th>
</tr>
</thead>
</table>
| Medicaid (also known as Apple Health) | Medicaid is jointly funded by states and the federal government. Medicaid currently provides dental coverage for both children and adults.  

a. Dental benefits were restored for adults receiving Medicaid in January 2013.  
c. Washington State Health Care Authority, 2014. Dollar amounts are rounded to the nearest million.  

| | | | |
| Medicaid provided by states and the federal government. Medicaid currently provides dental coverage for both children and adults. | 533,939 (FY 2012, adults receiving Medicaid did not have dental benefits at this time)  
c. Washington State Health Care Authority, 2014. Dollar amounts are rounded to the nearest million.  
c. Washington State Health Care Authority, 2014. Dollar amounts are rounded to the nearest million.  
| Public Employees Benefit Board | State employees receive dental coverage with no premium for a choice of plans that costs the state approximately $39-$45 per person per month.  
d. Employees can purchase dental coverage for their dependents by paying the additional cost of a family plan.  

f. Ibid. Family plans cost approximately $79-$135 total per month depending on the type of plan and the family members covered.  

i. Ibid.  
j. Ibid. Dollar amounts are rounded to the nearest million.  
k. Ibid.  
m. Mary Jo Currey, Washington State Department of Corrections (personal communication, August 27, 2014)  
n. Ibid. Dollar amounts are rounded to the nearest million.  

| | | | |
| | | | |
| Department of Corrections | States are constitutionally mandated to provide health care to inmates. The DOC provides “medically necessary dental care.”  

h. Ibid.  

i. Ibid. Dollar amounts are rounded to the nearest million.  

j. Ibid. | 14,336 (FY 2014)  

i. Ibid. Dollar amounts are rounded to the nearest million.  

j. Ibid. Dollar amounts are rounded to the nearest million. | $7 million (FY 2014)  

i. Ibid. Dollar amounts are rounded to the nearest million.  

j. Ibid. Dollar amounts are rounded to the nearest million. |
II. Research Approach

When WSIPP is asked by the legislature to identify what works (and what does not) in public policy, we implement a three-step research approach.

- Step 1: What works? What does not?
- Step 2: What makes economic sense?
- Step 3: What is the risk in the benefit-cost findings?

In this report, we focus on the first research step. We estimate whether various oral health interventions can achieve the desired outcome—the prevention of tooth decay. We carefully analyze all high-quality studies from the United States and elsewhere to identify policy options tried, tested, and found to impact outcomes. We look for research studies with strong evaluation designs and exclude studies with weak research methods.

Our empirical approach then follows a meta-analytic framework to assess systematically all credible evaluations we can locate on a given topic. Given the weight of the evidence, we calculate an average expected effect of a policy on a particular outcome of interest, as well as an estimate of the margin of error for that effect. We describe this method in detail in WSIPP’s Technical Documentation.7

Whenever possible, WSIPP conducts a benefit-cost analysis for an intervention using the effect sizes calculated in the meta-analysis.

We searched the dental and economic literature for studies linking tooth decay to outcomes such as medical complications, emergency department use, inadequate nutrition, academic performance, labor market earnings, and the need for restorative and emergency dental procedures. We did not find sufficient rigorous research to establish a cause-and-effect relationship between tooth decay in youth and outcomes that can be monetized over an individual’s lifetime. Therefore, we could not conduct a benefit-cost analysis.

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6 For this report we only include studies where outcomes are assessed by a clinician who is “blinded” (does not know who is and is not receiving treatment) when blinding was possible. Blinding was not always possible in studies examining sealants since sealants that are still attached to a tooth are often visible.

III. Research Results

Literature Review

WSIPP identified dental topics for analysis based on published recommendations from the U.S. Preventive Task Force and the Washington State Board of Health. We also consulted the Pew Charitable Trusts’ Children’s Dental Policy team and Washington State Department of Health’s Oral Health Program.

We conducted literature reviews on sealants, fluoride varnish, community water fluoridation, mid-level dental providers, and preventive dental visits. We found sufficient rigorous studies that measured patient-level outcomes to conduct a meta-analysis on three topics:

- fluoride varnish compared to no treatment,
- resin sealants on permanent molars compared to no treatment, and
- community water fluoridation.

Exhibit 3 describes these topics in greater detail. The studies measured only one outcome—tooth decay. None of the studies measured other outcomes of interest such as the use of dental and medical services, bone development, and fluorosis.

Since almost all of the rigorous studies on these topics evaluated the interventions on children and adolescents, we focused our analysis on youth. Children can experience tooth decay in their primary or permanent teeth. The fluoride varnish studies measured the effect of the intervention on both primary and permanent teeth. The evaluations of community water fluoridation and sealants only measured the interventions’ impact on permanent teeth.

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9 Citations for all studies that we reviewed are listed in the Technical Appendix.

Tooth decay
Tooth decay (also called dental caries or cavities) is caused by an infection that results in the destruction of tooth tissue. In this report we focus on decay that had reached the dentin (middle) layer of the tooth.

Fluoride varnish
Fluoride varnish is a form of fluoride that temporarily adheres to the tooth in order to maintain contact between the fluoride and the tooth for several hours. In the studies we reviewed, fluoride varnish was applied every three to six months over a 12- to 36-month time period.

Sealants
Sealants are plastic films applied to the biting surfaces of molars to prevent decay. Approximately 51% of 3rd grade students in Washington have sealants. Our analysis focuses on comparing the effectiveness of resin sealants to no treatment. We also examined the effectiveness of other sealant materials compared to resin sealants and we report these results in the Technical Appendix.

Community water fluoridation
Water contains naturally occurring fluoride at varying levels. Community water fluoridation refers to the addition of a fluoride compound to the public water supply to achieve a total fluoride level of 0.7-1.2 mg/L.

Exhibit 3
Description of Oral Health Outcomes and Interventions

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**Meta-Analysis Findings**

**Fluoride varnish.** Eleven out of 17 studies evaluating fluoride varnish on permanent teeth and five out of the eight studies on fluoride varnish on primary teeth met WSIPP’s criteria for scientific rigor. These studies contributed 14 effect sizes to the meta-analysis of fluoride varnish on permanent teeth and six effect sizes to the meta-analysis of fluoride varnish on primary teeth.

We found that fluoride varnish significantly reduces tooth decay in both primary and permanent teeth *(Exhibit 4).* Given the study population and calculated effect size, we would expect that 25% of permanent molars would have developed decay without fluoride varnish and 18% would have developed decay with fluoride varnish.\(^\text{11}\) Similarly, we would expect that 25% of primary molars would have developed decay without fluoride varnish and 19% would have developed decay with fluoride varnish.

**Resin sealants.** Ten out of the 11 studies that evaluated the application of resin sealants on permanent molars, compared to no treatment, met WSIPP’s criteria for scientific rigor. These rigorous studies contributed 12 effect sizes to the meta-analysis.

We found that the application of resin sealants significantly decreases tooth decay on permanent molars *(Exhibit 4).* Given the study population and calculated effect size, we would expect that 25% of molars would have developed decay without resin sealants and 6% would have developed decay with resin sealants.

We did not find a statistically significant difference between the performance of resin sealants and sealants of other materials *(Technical Appendix, Exhibit A1).* However, the analysis suggests that, on average, resin-modified glass ionomer sealants tend to perform better than resin sealants.\(^\text{12}\)

**Community water fluoridation.** Unfortunately, only two out of 11 studies we located on community water fluoridation’s impact on youth met WSIPP’s criteria for scientific rigor. The excluded studies either did not have an adequate comparison group or analyzed the impact of fluoride exposure from all sources including toothpaste and mouthwash.

The two included studies measured the effect of community fluoridation for approximately four years on children who were an average of ten years old when the studies began. Our results, therefore, do not reflect the effectiveness of community water fluoridation on younger and older members of the community who would also be exposed to this intervention.

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\(^{11}\) Since we could not find epidemiologic data describing the incidence of tooth decay, we estimated the incidence of tooth decay in molars using the average rate of tooth decay in the control groups of the studies that were included in this report. In the dental interventions that we reviewed, 25% of permanent teeth in the control group developed tooth decay over an average follow up period of 31 months.

\(^{12}\) This comparison approached statistical significance *(p-value=0.108).*
We found a significant decrease in tooth decay with community water fluoridation for this specific age group (Exhibit 4). Given the study population and calculated effect size, we would expect that 25% of molars would have developed decay without community water fluoridation and 12% of molars would have developed tooth decay with this intervention. We caution, however, that this finding is based on just two rigorous studies.

We found that sealants and fluoride varnish significantly reduce tooth decay in youth.

We also found that community water fluoridation reduces tooth decay in youth, although this finding is based on only two studies. Additional research is needed to fully characterize the impact of community water fluoridation. This research should include a range of age groups and measure other outcomes of interest.

We did not conduct a benefit-cost analysis on preventive dental interventions for youth because of a lack of longitudinal research on the economic and health consequences of youth tooth decay.
Meta-Analysis Methodology: Adjusting for Clustering

Many dental studies report data that are clustered. For example, outcomes may be reported for individual teeth which are clustered within a person. Analyses that do not account for clustering will underestimate the variance in outcomes at the tooth level and, thus, may over-estimate the precision of magnitude on effect sizes. In studies that do not account for clustering, effect sizes and their variance require additional adjustments.

In the dental literature we found two types of clustering: children clustered within schools and teeth clustered within an individual person. We used 2006 Washington Assessment of Student Learning (WASL) data to calculate values of the intraclass correlation coefficient ($\rho$) for the school-level clustering ($\rho = 0.114$).

When the unit of analysis was a tooth and data were reported as tooth pairs we used the binary correlation coefficient as the intraclass correlation coefficient. We calculated the binary correlation coefficient using the following method described by Elbourne et al., 2002:

$$\rho = \frac{ns - ab}{\sqrt{abcd}}$$

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14 Studies that employ hierarchical linear modeling, fixed effects with robust standard errors, or random effects models account for variance and need no further adjustment for computing the effect size, but adjustments are made to the inverse variance weights for meta-analysis using these methods.


where \( n \) is the total number of treatment and control units, \( a \) is the number of successful outcomes in the treatment group, \( b \) is the number of successful outcomes in the control group, \( c \) is the number of unsuccessful outcomes in the treatment group, and \( d \) is the number of unsuccessful outcomes in the control group. If data were not reported as tooth pairs, we used the mean binary correlation coefficient of the studies where it could be calculated.


In this analysis we considered adjusting effect sizes for the following reasons: research design, high-risk study population, and the use of a placebo control group. For a full description of the rationale for these types of adjustments see the WSIPP Technical Documentation.\(^{17}\)

Since there was little variation in the research design we were not able to investigate whether this factor produced systematically different effect sizes. We conducted a meta-regression to assess whether testing the intervention in a high-risk population or using a placebo treatment in the control group yielded systematically different effect sizes. We did not find any statistically significant differences based on these attributes and, therefore, present the unadjusted effect sizes in this report.

**A3. Meta-Analyses of Sealants of Different Materials**

We identified 12 rigorous studies that evaluated resin sealants on permanent molars compared to no treatment. We also identified rigorous studies that evaluated sealants of different materials compared to resin sealants (Exhibit A1).

We list the citations to all studies included in these meta-analyses at the end of this Technical Appendix.

### Exhibit A1
Meta-Analytic Results of Tooth Decay with Different Sealant Materials Compared to Resin Sealants

<table>
<thead>
<tr>
<th>Materials compared</th>
<th>No. of effect sizes</th>
<th>Effect sizes at two year follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ES</td>
</tr>
<tr>
<td>Glass-ionomer sealants (earlier generation, e.g., Fuji III) compared to resin sealants</td>
<td>7</td>
<td>-0.016</td>
</tr>
<tr>
<td>High viscosity glass-ionomer sealants compared to resin sealants</td>
<td>3</td>
<td>0.096</td>
</tr>
<tr>
<td>Poly-acid modified resin composite sealants compared to resin sealants</td>
<td>3</td>
<td>-0.075</td>
</tr>
<tr>
<td>Resin-modified glass ionomer sealants compared to resin sealants</td>
<td>4</td>
<td>0.304</td>
</tr>
</tbody>
</table>

A4. Reviewed Studies Included in the Meta-Analyses

**Resin sealants compared to no treatment**


**Fluoride varnish on permanent teeth**


**Fluoride varnish on primary teeth**


**Community water fluoridation**


**A5. Reviewed Studies Excluded from the Meta-Analyses**

**Resin sealants compared to no treatment**


**Fluoride varnish on permanent teeth**


**Fluoride varnish on primary teeth**


**Community water fluoridation**


A6. Reviewed Studies Included in the Meta-Analyses of Different Sealant Materials

**Glass-ionomer sealants (earlier generation, e.g., Fuji III) compared to resin sealants**


**High viscosity glass-ionomer sealants compared to resin sealants**


**Poly-acid modified resin composite sealants compared to resin sealants**


Resin-modified glass ionomer sealants compared to resin sealants


The Washington State Legislature created the Washington State Institute for Public Policy in 1983. A Board of Directors—representing the legislature, the governor, and public universities—governs the Institute and guides the development of all activities. WSIPP’s mission is to carry out practical research, at legislative direction, on issues of importance to Washington State.