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Delta Dental of Minnesota Foundation

The Value of Supporting Access to Dental Care

An Economic Review of the Impacts of Dental Interventions

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Introduction

The Delta Dental of Minnesota Foundation invests millions of dollars annually in their grantees' efforts to improve the dental health of Minnesotans. Seeking to better capture the value of these grant-funded improvements, the Foundation requested a return on investment (ROI) analysis as one component of their 2018-19 evaluation and needs assessment study conducted by Wilder Research.

In the effort to quantify the ROI of the grants funded by the Foundation, Wilder Research encountered some important gaps in the available data and literature. Most critically, there is an overall lack of published, high-quality research on the economics of dentistry (Morgan et al., 2012; Shariati, MacEntee, & Yazdizadeh, 2013; Tonmukayakul, Calache, Clark, Wasiak, & Faggion, 2015) and, more generally, research on the impacts of dental interventions (Mariño, Khan, & Morgan, 2013; Mejàre et al., 2015).[1] In addition, the current tracking system for the Foundation's grant outcomes is somewhat limited in detail on the number and types of services provided, causing some difficulty in developing ROI estimates. With these gaps, it is not currently possible to concretely link the grant-funded efforts to the dental outcomes that can be quantified.

Although we are not able to compute the ROI of the Foundation's grant-funded activities, we have compiled the results of our review of the literature as it pertains to the benefits of dental care. In consolidating this information, we hope that this document may serve as a valuable resource, particularly as future research fills the gaps in the literature and improves the feasibility of ROI analysis related to dental care interventions.

This document summarizes the known effects of several dental interventions on a variety of quantifiable outcomes, including dental decay and caries risk, the number of restorative care visits and their associated costs, emergency department visits, and quality of life. Where possible, we present the monetary value of these outcomes.

For some outcomes (quality of life, for example), existing research may measure the impact of dental care without quantifying the monetary value of the outcome. Though not monetized, we recognize that pain reduction and ability to function in life (two components of oral-health-related quality of life) are among the most important outcomes of the Foundation's work. For this reason, where the existing research quantifies the quality of life improvements resulting from dental care, we include these estimates. The same is true for other impacts that are not yet measurable in dollar terms.

Documented effects of dental care

Although the limitations in the literature make it infeasible to estimate the ROI of the Foundation's grant-funded activities at this time, the existing literature quantifies a number of benefits that have been linked to dental care. We summarize many of these estimated effects below.[2]

Impacts of dental interventions for children

This section reviews many of the known impacts of dental interventions for children, beginning with what we have found to be the most thoroughly studied interventions: preventive visits and dental sealants. Preventive visits and sealants have been shown to save up to $60/year and $36/year per child (respectively) in reduced non-preventive care costs, saving an average of 0.57 visits/year and 0.49 visits (total) per child, respectively (Figure 1).[3] Preventive visits and sealants have been shown to significantly reduce tooth decay and caries risk, and sealants have been linked to fewer emergency department visits.

The effects shown in Figure 1 are among the simplest and most concrete benefits to quantify, but they do not include some of the most meaningful potential impacts of dental care for children: improved quality of life, and the corresponding impact on attendance and performance in school. In reviewing the literature on the subject, Ribeiro, Almeida, Medonca, and Leal (2018) found insufficient evidence to link oral health to children's academic performance, but attributed this largely to the lack of high-quality studies that use appropriate measures of oral health and academic performance. As a result, while the theoretical link between oral health and academic performance is difficult to dispute, we are unable to point to solid evidence of that link.[4]

1. Impacts of dental interventions for children

Outcome	Impact of Preventive Visits	Impact of Sealants (Clinic-Based)	Impact of Sealants (School-Based)
Avoided costs of non-preventive dental services	$36-60/year (younger) $29-51/year (older)[a]	$21/year (younger) $36/year (older)[c]	$53[e]
Avoided non-preventive dental visits	0.18-0.57 visits/year (younger) 0.22-0.36 visits/year (older)[a]	0.07 visits/year (younger, ns) 0.11 visits/year (older)[c]	0.49 visits[e]
Avoided emergency room visits	Effect size not found	0.2 visits/year (younger and older)[c]	Effect size not found
Avoided decayed surfaces/reduced caries risk	2.0 deciduous surfaces 3.8 permanent surfaces[b]	Caries risk reduced by 34 percentage points (range: 11-51 percentage points)[d]	

Note. All dollar values are in 2018 inflation-adjusted USD. All effects reported above are on a per-child basis, and were identified by the original authors as statistically significant unless they are marked here as "ns" (not significant). Where possible, effects are differentiated for younger and older children, with age ranges defined in the notes below.

[a] Sen et al. (2013): Range of values refers to the differing impact of one to three preventive visits in the prior year, with greater non-preventive savings associated with more preventive visits, and a declining marginal return to each additional preventive visit. Non-preventive dental visits included those with restorative, endodontic, periodontic, and all other dental procedures. "Younger" children were younger than 8 years, and "older" were 8 years or older.

[b] Enciso, Sundaresan, Yekikian, and Mulligan (2015): The authors compared the mean numbers of decayed deciduous and permanent surfaces between children who were visiting a mobile dental clinic for the second time to a statistically matched group of children visiting the clinic for the first time.

[c] Sen et al. (2016): Non-preventive visits include visits labeled as restorative, nontraumatic dental emergency, endodontic, or periodontic. Younger children were age 4 to <9, older were age 9+. Sealant intervention was defined as one or more sealants applied in the prior 3 years, as identified by a Medicaid claim. Outcomes were measured using the fourth year of study data.

[d] Ahovuo-Saloranta et al. (2017): In reporting the results of their meta-analysis of the data from seven randomized trials (based in clinic and school settings) studying the effectiveness of resin-based sealants in 5-to-10-year-old children at 24-month follow-up, they present a broad effect size range because the interpretation of their estimate (a Becker-Balagtas marginal odds ratio of 0.12) depends on the prevalence of caries in the control population. With a control group caries rate of 40% (a reasonable approximation for the 46% caries rate among U.S. children (Fleming & Afful, 2018)), the treatment group caries rate of 6% is 34 percentage points lower than in the control group. The authors find similar results at 48-month follow-up, but these results are based on a lower quantity and quality of evidence.

[e] Griffin et al. (2016): Using conservative estimates of school-based sealants' caries prevention effectiveness and the cost of fillings, the authors compute the net present value of four-year avoided costs and fillings attributable to sealants of the first four molars, assumed to be applied between the ages of 6 and 7. In addition to the $53 avoided cost, the authors estimate a $21.34 gain in parental productivity due to the avoided clinic visit. To be consistent with estimates of avoided costs presented elsewhere in this figure, we have excluded this productivity gain. The authors estimate that sealants avoid 0.49 fillings. We have assumed that this translates to the avoidance of 0.49 non-preventive visits (one visit per filling).

Of course, in order to reap the benefits of preventive care, a child must have access to a dentist. A greater distance between a child's home and their nearest dentist has been shown to significantly reduce the child's likelihood of receiving a comprehensive dental exam and other preventive services (Wehby et al., 2017).

In addition to the effects shown in the table above, the existing literature includes a number of other positive impacts of dental care. Selected examples are summarized below.

- After receiving comprehensive dental treatment, children experienced significant improvements in several measures of oral-health-related quality of life (Alkarimi et al., 2012; Anderson, Drummond, & Thomson, 2004), including reduced pain, reduced sensitivity, and improved appetite.
- Relatedly, preschool children with dental caries have been found to be more likely than children without caries to be underweight, but they gained weight and caught up to their peers after dental treatment (Sheiham, 2006).

Impacts of dental interventions for adults

Our review of the literature uncovered few studies of the impact of dental care on adults, and the available literature is based largely on self-reported outcomes for relatively small subsets of the population. Despite the narrow populations reflected, these studies may offer valuable insights into the potentially significant impacts of dental care. We now review the documented impacts of several categories of dental interventions.[5]

Restorative care

In a handful of studies (on fairly narrow populations), restorative care has been found to significantly improve patients' quality of life and employment/financial situations:

- **Oral-health-related quality of life improved significantly** in a population of California welfare recipients after they received the restorative care they needed (Hyde, Satariano, & Weintraub, 2006).[6]
- In a population of formerly homeless veterans in a transitional housing program, **those who received dental care were significantly more likely to have a job or financial stability** at the time of discharge, compared to a comparable group of participants who did not receive dental care (Nuñez, Gibson, Jones, & Schinka, 2013).[7]
- Several other studies have examined the link between restorative care and employment outcomes. They tend to find **some evidence that restorative dental care improves perceived or actual employment prospects, employability, self-esteem, and self-image**. However, due to the studies' methodological limitations, these impacts require further study (Singhal, 2015; Singhal, Correa, & Quiñonez, 2013).[8]

Preventive care and oral screening

Due to data limitations, few studies have examined the impact of preventive care and oral screening for adults. The few existing studies tend to show that these efforts have value, though. For example:

- Glied and Neidell (2010) found that childhood **exposure to community-level fluoridated water was associated with 4% higher earnings among women**, an effect they attributed to employment discrimination based on standards of oral health and beauty that were imposed disproportionately on women (they found no effect on men's earnings).
- In a study of Medicare beneficiaries, Moeller, Chen, & Manski (2010) showed that **preventive care (1+ dental cleaning in the year) was associated with fewer nonpreventive visits and lower dental expenses** (both nonpreventive care expenses and total dental expenses).
- Among those diagnosed with oral or pharyngeal cancer, **those who went to the dentist regularly (annually or more frequently) were more likely to be diagnosed at an earlier stage and to have a lower T classification** (smaller tumors) than those who went to the dentist more rarely (Langevin et al., 2012).
- **In high-risk populations (users of tobacco and/or alcohol), oral screening has been shown to reduce oral cancer mortality rates by 24%**, though the study was based in India and their results may be somewhat biased.[9]

Although the available literature is limited, these studies suggest that we may expect to see further evidence of the value of preventive dental care for adults, if additional research were conducted.

Oral health education

The literature covering the value of oral health education for adults is similarly rare, but similarly promising:

- In a small study of older adults, Hjertstedt, Barnes, & Sjostedt (2014) found that **oral health education significantly improved the participants' oral health literacy and oral hygiene** (as measured by their plaque index scores).
- A Japanese **workplace oral health education program reduced participants' total dental expenditures** over the three-year study follow-up period, while the control group's expenditures increased over the same period (Ide, Mizoue, Tsukiyama, Ikeda, & Yoshimura, 2001).

Availability of dental care[10]

The availability of convenient dental care has been shown to be a significant factor in the use of dental services and in the reduction in use of the emergency department for non-traumatic dental needs:

- In Ohio, **older adults were more likely to use dental services if they lived in counties with higher dentist-to-population ratios** (Lee, Kim, Albert, & Nelson, 2014).
- A **community dental access program in rural Maryland provided urgent dental care to 1,600 clients (in 2,700 visits) over four years, avoiding an estimated 670 emergency room visits that would have cost an additional $228,000** (Rowland, Leider, Davidson, Brady, & Knudson, 2016, adjusted for inflation to 2018 USD). The authors concluded that this model of averting emergency room visits could be a cost-effective means of improving access to dental care.

Other cost-effective approaches

In reviewing the existing economic evaluations of dental practices, we identified two approaches that could potentially generate cost savings: the use of an intermediate dental professional position (a dental therapist), and silver diamine fluoride treatment to arrest tooth decay in young children and older adults.

Dental therapists

In recent years, some states have introduced dental therapists, a role between the level of dental hygienists and dentists, to complete some restorative, extraction, and pulpal services, freeing state-licensed dentists to dedicate their time to more sophisticated procedures that require their advanced training. Existing research has confirmed that the dental therapist position can yield cost savings (Wagner, Ferris, & Diaz, 2017a, 2017b), though Beazoglou, Bailit, DeVitto, McGowan, & Myne-Joslin (2012) estimated that the dental therapist position could yield at most a 6% reduction in costs.

Silver diamine fluoride (SDF) treatment

- Based on the estimated effectiveness of SDF treatment to arrest tooth decay in primary teeth (children age 1-5), Johhnson, Serban, Griffin, & Tomar (2019) concluded that this could be a net cost-saving approach that also avoids more stressful restorative treatment options.
- In their review of the literature on SDF effectiveness among older adults, Hendre, Taylor, Chávez, & Hyde (2017) concluded that SDF is effective in arresting and preventing new caries in older adults.

Conclusions and issues to consider

In this analysis, we set out to quantify the return on investment associated with the Foundation's grant-making activities. Although we found that insufficient data were available to fully execute this task, we uncovered a great deal of evidence supporting an unsurprising but important conclusion: oral health, and the dental care that supports it, is valuable. Even without the particular set of literature required to fully quantify and sum up the various benefits of oral health and dental care, our review of the literature has identified and summarized a number of relevant findings supporting the value of oral health and, by extension, the Foundation's activities that support oral health in Minnesota.

Regarding the oral health interventions that have been evaluated rigorously for their cost-effectiveness, the evidence indicates that they generate more than enough value to justify their cost. For example, we have summarized the net savings generated by sealants, preventive care visits, and applications of silver diamine fluoride in children's oral health care.

The value of restorative care is generally more difficult to measure, even when the links are intuitively clear. For example, it is not difficult to imagine how a toothache could keep a student from doing their best work and, by extension, how chronic untreated dental problems could dramatically alter their path through school, potentially affecting their career path in the long run. We can also see how restorative care can be truly life-changing for people experiencing severe discomfort and loss of function due to oral health problems, and can even improve financial stability and employment prospects in adults. Unfortunately, the body of rigorous research lags behind what we know intuitively, so we have been able to identify but not quantify these sorts of benefits of restoring oral health.

Without the ability to quantify the benefits of the various strategies employed to improve oral health, we are unable to answer a key question that motivated this analysis: which strategies offer the greatest value per dollar invested? With the information available at this time, it is not possible to develop an apples-to-apples comparison of the different benefits, and, without such a comparison, an economic analysis cannot offer concrete guidance on the most cost-effective strategies to prioritize in future efforts.

While we cannot offer specific guidance on prioritizing particular strategies, the other components of the Foundation's evaluation and needs assessment may aid in prioritizing the geographic areas with greatest need. In addition, given that 80% of oral disease occurs in only 20% of the population, effective targeting is key to making the best use of available resources (United States General Accounting Office, 2000).

Importantly, though lacking in some of the specifics required for the goals of this analysis, the field has amassed a solid and growing body of evidence of the effectiveness and value of many oral health interventions that have been funded by the Foundation. As a result, we can affirm that the Foundation has invested in a variety of valuable interventions to help improve the overall state of oral health in Minnesota.

In addition, the current state of the literature offers a number of exciting opportunities to enhance the field and enable future economic analysis that builds on the work we have begun. We list some of these opportunities below.

Opportunities for future research

As noted above, the literature is limited in its coverage of the economic benefits of dental care. Some of the most notable pieces missing in the literature include:

- **Data illustrating the impact of new or expanded dental clinic capacity in an underserved area.** It has been established that clinic proximity is a key determinant of the use of dental services, but we have not encountered any study that quantifies the net impact on the quantity of patients served or services received. With a high proportion of Foundation funds being directed to increase care capacity in underserved areas, estimating this impact is critical to capturing the full value of philanthropic efforts like these.
- **Rigorous identification of the relationship between oral health and other health conditions, such as heart disease and diabetes.** Correlations have been identified, but it has proven quite difficult to determine whether oral health drives these other health conditions or vice versa, or whether all are driven by other factors (Pihlstrom et al., 2018).
- **Consistent confirmation of the cost-effectiveness of preventive care.** Because many studies lack the appropriate data to control for the selection factors that underlie an individual's pursuit of dental care, these studies tend to arrive at counterintuitive conclusions that raise confusion in the field.
- **Estimates of the quality of life gains due to prevention and treatment of painful dental health conditions.**
- **An estimate of the monetary value of these quality of life gains.** Studies of willingness to pay, which are currently rare and limited in quality (Tan, Vernazza, & Nair, 2017) in the dental field, would yield an estimate of the value that individuals assign to the functions addressed in the oral-health-related quality of life scales.

In future efforts to develop ROI capacity in the dental care field, addressing the literature gaps listed above could radically improve our ability to compute the monetary value of the many benefits of dental care.

The literature also offers little guidance on the most effective delivery mechanisms for achieving positive outcomes in oral health. It may be difficult to compare mechanisms to develop this sort of guidance because different interventions tend to target varying outcomes, so apples-to-apples comparisons are rarely possible. With advances in the literature (addressing the gaps identified above), ROI analysis can enable reasonably effective comparisons of mechanisms by converting the various outcomes to their monetary values. There may well be other means of comparing and prioritizing the many potential uses of grant funds, and the field would benefit greatly from further development in this area.

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[1] Mejare et al. (2015) found little quality clinical evidence on the impacts of dental interventions in their review of the pediatric dentistry literature, and, based on our review of the literature, the available information on the impacts of adult dental interventions is even more limited. Dental studies tend to be hindered by selection bias (because those who seek out dental care tend to be those who experience dental problems). Relatively few studies in the literature have the right kind of data (longitudinal) to be able to control for that issue and effectively measure the effects of these interventions. As a result, the literature contains many studies that show no significant effect (or the opposite effect that would be expected).

[2] In compiling these estimates, we hope this may serve as a valuable resource in future efforts to compute the ROI of a given set of dental interventions. Some of the impacts of dental interventions are measured in dollars and could be directly applied in a future ROI analysis. For example, Sen et al. (2016) found that the application of at least one sealant for a child age 9+ results in $36 in annual cost savings (on average) for non-preventive dental services up to three years later (Figure 1). If we assume these savings apply over an average of three years, the total savings ($108) can be compared to an estimate of the per-child cost of providing dental sealants in order to compute a partial ROI estimate of dental sealants. (This would be considered a partial ROI estimate because it fails to account for any benefits of sealants other than the avoided costs of future non-preventive dental services. Note also that the three-year estimate of cost savings of $108 is an oversimplification for the purpose of illustrating the general concept. Savings accruing in future years should be discounted to provide an estimate of net present value.)

[3] Note that the available guidance on the transferability of health economics evaluations across jurisdictions suggests that unit values (estimates of costs, savings, etc.) should be adjusted based on locally specific data (Drummond et al., 2009), though this may not always be feasible, depending on local data availability and the level of detail provided in the study whose values are transferred. Dollar value estimates presented in this document have not been revised to account for these jurisdictional differences.

[4] In one possible exception to the shortage of reliable findings in this field, Guarnizo-Herreño and Wehby (2012) showed significant links between students' dental problems (toothache, decayed teeth or cavities, or bleeding gums) and the students' odds of missing school days, failing to complete homework, and reporting feelings of shyness, worthlessness, and unhappiness. Ribeiro et al. (2018) dismissed this study because the outcomes are based on data reported by students' mothers, rather than observational data (dental exams and test scores). In addition, Edelstein and Reisine (2015) found several examples of the associations between dental issues and academic achievement in the existing literature, but the studies tended to fall short of the methodological rigor required by Ribeiro et al. (2018).

[5] Note that this review does not include the possible impacts of improvements in oral health on other systemic diseases, such as diabetes. Although a number of studies have illustrated the links between oral health and other general health indicators (see examples in Vargas & Arevalo, 2009), the available literature has not established the causality of these associations. Pihlstrom, Hodges, Michalowicz, Wohlfahrt, & Garcia (2018) concluded that, at this time, there is no definitive evidence that treating oral disease significantly affects or prevents other systemic health issues.

[6] After a population of California welfare recipients identified as needing extraordinary dental services were given restorative treatment, their scores on the 56-point "OHIP-14" oral-health-related quality of life assessment improved by 11.6 points. The authors computed an effect size of 0.87, considered to be a large effect. They also found at least moderate effects on the subscales of psychological discomfort, psychological disability, handicap, social disability, and physical pain. For more information on the interpretation of oral-health-related quality of life, see Reissmann, Sierwald, Heydecke, and John (2013) and Sischo and Broder (2012).

[7] In the full population of residents, recipients of dental care were 14% more likely to have a job or financial stability. Among residents who had reported a complaint about their dental health at entry, those who had received dental care (preventive or restorative) were 20% more likely to have a job or financial stability at discharge, compared to those who did not receive dental care.

[8] Singhal et al. (2013) reviewed the small body of literature on the impact of dental care on employment outcomes and found that the studies generally relied on small samples or had no control group to whom they could compare the intervention group's outcomes. Singhal (2015) also conducted a larger-scale Canadian study of the link between dental treatment and the change over time in the proportion of social assistance (welfare) recipients who became employed. Even though social assistance recipients who received dental treatment were less likely to leave social assistance during the study's one-year time frame compared to those who did not receive dental treatment (a difference that is likely attributable to greater barriers at entry for those who required dental treatment), Singhal found that those who received dental treatment saw a significantly greater *change* in likelihood of leaving social assistance over the one-year time frame (a 124% increase, compared to an 83% increase among those who did not receive dental treatment). This may be considered further evidence that dental treatment may help disadvantaged members of society "catch up to" more privileged others by improving their employment prospects and/or confidence to pursue these opportunities.

[9] Brocklehurst et al. (2013) reviewed the literature on the impacts of oral cancer screening, but found only one RCT study (of over 190,000 participants in Kerala, India) that they deemed suitable to include in their final analysis. While this study did find a reduction in mortality rates in the high-risk population, they found no impact on mortality rates in the overall study population. However, in the overall study population, the screened participants who were diagnosed with oral cancer were significantly less likely than others to receive a diagnosis of stage III or higher, suggesting that screening does aid in earlier detection in a broader population (even if this did not translate to reduced mortality rates in the 15-year study period).

[10] Due to our focus on dental interventions directly funded by the Foundation, we have not discussed literature related to the impact of dental insurance on use of dental care.

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