

A Comparative Expected Cost Analysis Study on Dental Services and Products Used in the United States

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ABSTRACT: The present comparative analysis study conducted expected cost analysis on 32 dental services and products used in the United States. The expected cost of the 32 products and services were determined by dividing cost with effectiveness. The products and services were then ranked in terms of value within each of the following categories: 1) nine teeth whitening products (whitening strips, on-line bleaching tray, dental office bleaching, dental office take home tray, baking soda toothpaste, lemon juice, whitening toothpaste, whitening mouthwash and charcoal toothpaste), 2) three teeth straightening products (Smile Direct Club, Invisalign and orthodontic braces), 3) four filling types (gold cast, ceramic, silver amalgam and composite resin), 4) four types of crowns (resin, porcelain, porcelain-fused metal and metal), 5) six tooth decay treatment options (root canal, extraction, dentures, traditional veneers, no prep veneers and implants and 6) six tooth decay prevention options (water fluoridation, fluoride mouth wash, fluoride toothpaste, silver diamine fluoride solution, professional flossing & cleaning with fluoride, professional flossing & cleaning) were evaluated. It was found that the hydrogen peroxide gel strips provided the most value in whitening teeth and Smile Direct Club provided the most value to straighten teeth. Community fluoridated water provided the most value reducing the prevalence of cavities and dental insurance did not provide value reducing overall patient dental costs. The present study did not find a significant difference between the cost to prevent a cavity and the cost to fill a cavity. The expected cost to prevent a cavity by community fluoridated water was \$11 per year and the expected cost to prevent a cavity using fluoridated mouth rinse was found to be \$16 per year, while the expected annual cost of an amalgam filling was \$16.24.

KEYWORDS: Cost Analysis, Teeth Whitening, Teeth Straightening, Fillings, Crowns, Root Canal, Extractions, Implants, Cavity Prevention

INTRODUCTION

The American Dental Association Health Policy Institute reported that United States national dental expenditures were \$124 billion in 2016, up from \$120 billion in 2015 — a 3.3% increase (Garvin, 2016). This purpose of this study was to determine value and did not take into consideration personal preferences or personal value for individual consumers. Treatments with better success rates may not provide more value due to higher costs.

This present study, conducted expected cost analysis on 32 products and services. This was determined by dividing the cost with effectiveness or success rate (SR) and then ranking them in terms of value within each of the following categories: 1) nine teeth whitening products (whitening strips, on-line bleaching tray, dental office bleaching, dental office take home tray, baking soda toothpaste, lemon juice, whitening toothpaste, whitening mouthwash and charcoal toothpaste), 2) three teeth straightening products (Smile Direct Club, Invisalign and orthodontic braces), 3) four filling types (gold cast, ceramic, silver amalgam and composite resin), 4) four types of crowns (resin, porcelain, porcelain-fused metal and metal), 5) six tooth decay treatment options (root canal, extraction, dentures,

traditional veneers, no prep veneers and implants, and 6) six tooth decay prevention options (water fluoridation, fluoride mouth wash, fluoride toothpaste, silver diamine fluoride solution, professional flossing & cleaning with fluoride, professional flossing & cleaning).

Tooth Decay Prevention

None of the 12 reviewed studies reported that flossing plus brushing was effective at preventing tooth decay (Sambunjak, Nickerson, Poklepovic, Johnson, Imai, 2011). Hujuel (2006) reported most of the clinical evidence has not indicated that dental floss is effective at reducing tooth decay, but there is strong evidence that flossing effectively reduces risk of periodontal diseases. Brushing and flossing help, but they are not able to prevent cavities since plaque often begins within tiny cracks and in the enamel unreachable by flossing and brushing.

Semi-annual topical application of silver diamine fluoride (SDF) solution reduced cavity rates by 91% in children (Zhi, Lo, Lin, 2012). The use of 0.2% sodium fluoride mouthwash decreased tooth decay by 45% among school age children (Aminabadi, Balaei, Pouralibaba, 2007). According to Marinho (2003), 3.7 children using fluoride toothpaste

“A Comparative Expected Cost Analysis Study on Dental Services and Products Used in the United States”

will avoid one decayed tooth per year, an effectiveness rate of 27% (1/3.7). The American Dental Association (2012) estimates the average cost for a community to fluoridate its water ranges from 50 cents per year per person in large communities to \$3 per year per person in small communities.

The effectiveness or success rate (SR) of self and professionally applied fluoride and water fluoridation among adults in preventing cavities was 29% and the prevented fraction for water fluoridation was 27% (Griffin, Regnier, Griffin, Huntley(2007). Professional flossing with low fluoride exposure reduces risk of cavities by 40% (Hujoel, 2006), which suggests that professional flossing without fluoride reduces the prevalence of cavities by 11% (40% – 29%). Gisselsson (1994) reviewing four studies reported that when there was no fluoride exposure, flossing did not provide value.

Tooth Decay Prevention	SR	Unit Cost	Annual Cost	Expected Cost
Water Fluoridation	27%	\$3	\$3	\$11
Fluoride Mouth wash	45%	\$4	\$16	\$36
Fluoride Toothpaste	27%	\$3	\$12	\$44
Silver Diamine Fluoride Solution	91%	\$42	\$84	\$92
Flossing	11%	\$2	\$12	\$109
Professional Flossing / Cleaning (fluoride)	40%	\$100	\$200	\$488
Professional Flossing / Cleaning	11%	\$100	\$200	\$1,818

It was reported that 74.4% of communities in the United States have fluoride in their water (CDC, 2014). Fluoridation was found to be the most effective measure to prevent tooth decay. Fluoride prevents mineral loss in tooth enamel, replaces lost minerals and reduces the ability of bacteria to make acid. According to the National Institute of Dental and Craniofacial Research (2019) economic analysis determined that for every \$1 invested in community fluoridation saves \$38 in treatment costs. Excess amounts of fluoride ingestion could cause fluorosis which affects both the teeth and bones. Moderate amounts of fluoride can lead to dental effects and long-term ingestion of large amounts can cause skeletal problems. Chronic high-level exposure to fluoride can lead to skeletal fluorosis. In skeletal fluorosis, fluoride accumulates in the bone progressively over many years. However, chronic high-level exposure to fluoride is rare (WHO, 2019).

Tooth Fillings

Adults aged 20 to 64 average 3.28 decayed or missing permanent teeth (National Institute of Dental and Craniofacial Research, 2019).Teeth can be filled with gold, porcelain, silver amalgam or a tooth-colored composite resin. A four surfaced tooth-colored composite resin filling that lasts 5 + years costs \$278 and looks more natural than the four surfaced silver dental amalgam that lasts 10 – 15 years and costs \$203 (2018 Allegiant Care Dental Fee. Schedule).Gold cast fillings cost up to 10 times more than cost of silver amalgam fillings and last 10 – 15 years (WebMD, 2019). Ceramic fillings (porcelain) last more than 15 years and can cost as much as gold fillings (WebMD, 2019).

Tooth Fillings	Life Span in Years	SR	Unit Cost	Annual Cost	Expected Cost
Amalgam	10–15	83 %	\$203	\$16.24	\$243
Composite	5–7	40 %	\$278	\$46.33	\$695
Ceramic	15 +	100 %	\$2,000	\$133	\$2,000
Gold Cast	10-15	83 %	\$2,000	\$160	\$2,400

The annual cost (cost divided by life span) was \$160 for the gold filling, \$133 for the ceramic (porcelain), 46.33 for the composite resin and \$16.24 for the silver amalgam. The silver amalgam had the lowest annual cost at \$16.24, but the tooth-colored composite resin is more popular. There is an annual cost difference of \$30 (\$46-16) between the composite resin and the silver amalgam, which translates to a daily cost of around 8 cents (365 days / \$30) and possibly less if covered by dental insurance plan.

Tooth Decay Treatment

The cost for root canal treatment performed by a general dentist averages \$445 for an incisor,\$660 for a molar and the fees charged by endodontists could be up to 50% higher (WebMD, 2019). The primary alternative to a root canal procedure is a tooth extraction. A root canal treatment has a 95% success rate and the fixed teeth can last a lifetime (WebMD, 2019).

A \$250 extraction can cause problems in the remaining teeth (gingival pocket), which could result in one having to spend \$3,500 for a dental implant (WebMD, 2019).If there is a 25% chance that a patient needs an implant after an extraction, then the expected cost of the extraction would be an additional \$875 (\$3,500 * .25). Therefore, the total expected cost of a \$250 extraction would be \$1,125 (\$250 + \$875), which is more than the cost of a root canal.

“A Comparative Expected Cost Analysis Study on Dental Services and Products Used in the United States”

Type	Life Span in years	SR	Unit Cost	Annual Cost	Expected Cost
Root Canal	-	95%	\$800	-	\$842
Extraction	-	-	\$250	-	\$1,125
Dentures	7-10	50%	\$1200	\$194	\$1,650
Veneers-T	10-15	100%	\$2500	\$200	\$2,500
Veneers-NP	5-7	100%	\$2000	\$333	\$2,000
Implants	5 - 15	100%	\$3500	\$350	\$3,500

Dentures cost \$1,200 and there is a 50% probability that denture patients will lose a dental piece and need a partial denture that costs \$900 (\$900 * 50% = \$450). Therefore, the expected cost of dentures would be \$1,650 (\$1,200 + \$450). Traditional veneers cost up to \$2,500 per tooth and last 10 to 15 years. No-prep veneers cost up to \$2,000 per tooth and last between 5 to 7 years. In the long-term, traditional veneers are often the more cost-effective option (Gotter, Frank, 2018). Veneers are more attractive than crowns and those who opt for veneers may later change for a crown, but not the other way around. The more aesthetically appealing implants cost \$3,500 (Doheny, 2019).

Crowns

Fillings protect a tooth’s internal damages, while crowns protect the outside area of the tooth. The average cost for a resin crown is \$422, the average cost for a porcelain-fused crown is \$633, the average cost for a metal crown is \$633 and the average cost for porcelain crown is \$642 (Allegiant Care 2018 Dental Fee Schedule). Resins are the least expensive (\$422), but are more likely to wear down or fracture.

Porcelain-fused-to-high noble metal crowns (\$633) are stronger than a porcelain crowns and made to match tooth’s original color, but the porcelain can wear down over time leaving the metal showing. The less attractive metal crowns (\$633) are long-lasting and better suited for back molars. Porcelain crowns (\$642) are the most popular choice because they closely match the tooth’s original, natural look and often improve upon the original. The life span for a resin, porcelain and porcelain fused metal crowns are 5 – 15 years, while metal crowns might last for 20 years or even longer.

Crown Type	Life Span	Cost	Annual Cost
Metal Crown	20	\$633	\$31.65
Resin Crown	10	\$422	\$42.20
Porcelain-Fused Metal	10	\$633	\$63.30
Porcelain Crown	10	\$642	\$64.20

Teeth Whitening

Cosmetic tooth bleaching was a \$3.15 billion global industry in 2016 and is expected to grow to 3.78 billion by 2021 (Business Wire, 2019).

An on-line search of Amazon retailers found that whitening rinses cost around \$6, while whitening toothpaste cost around \$4. Whitening toothpastes don’t change the natural color of teeth since the bleaching ingredient in whitening tooth pastes is often quickly washed away. For bleaches to work they must be in contact with the teeth for an extended period, as they do with bleaching trays or whitening strips (Salinas, 2019). Whitening toothpastes and the mouth rinses showed similar color alteration after a 12-week treatment period (Torres, Perote, Guterrez, Pucci&Borges, 2012). A randomized clinical trial evaluating whitening potential of commercially available toothpastes found that there was no noticeable visible color change other than stain removal (Horn, Bittencourt, Gomes, Farhat, 2014).

There is no evidence that remedies promoted online as being natural whitening agents, such as charcoal toothpaste (\$10), baking soda toothpaste (\$4) or lemon juice (\$4) actually work (ADA, 2018). Prescription strength whitening conducted in a dentist's office can make teeth three to eight shades lighter (webMD.com, 2019). Participants using 15% hydrogen peroxide gel showed better color stability than participants given a 6% hydrogen peroxide gel (Maran, Ziegelmann, Burey, de Paris Matos, Loguercio, Reis, 2019). A 14% hydrogen peroxide gel strip (\$20) resulted in 42 to 49% greater improvement in teeth whitening than the 6% hydrogen peroxide whitening strip (Gerlach, Sagel (2004).

The tooth-whitening gel provided significant tooth shade lightening relative to baseline tooth shade for up to 6 months (Sielski, Conforti, Stewart, Chaknis, Petrone, DeVizio, Volpe, Proskin, 2003). A tooth whitening gel containing 25% carbamide peroxide and a tooth whitening gel containing 8.7% hydrogen peroxide provided significant tooth shade lightening relative to baseline tooth shade. The results also showed that there was no statistical difference in tooth whitening efficacy between the two tooth whitening gel products (Nathoo, Stewart, Petrone, Chaknis, Zhang, DiVizio, Volpe, 2003).

Product	SR	Cost	Expected Cost
Whitening Strips	35%	\$20	\$57.14
On-Line DIY Bleaching Tray & Kit	37.5%	\$30	\$80.00
Dental Office Bleaching	100%	\$650	\$650.00
Dental Office Take Home Tray	37.5%	\$350	\$933.33
Baking Soda Toothpaste	-	\$4	-
Lemon Juice	-	\$4	-
Whitening Toothpaste	-	\$4	-
Whitening Mouthwash	-	\$6	-
Charcoal Toothpaste	-	\$10	-

“A Comparative Expected Cost Analysis Study on Dental Services and Products Used in the United States”

Dental office bleaching (\$650) uses bleaching gels with concentrations of hydrogen peroxide up to 40% while the dental office home-kits (\$350) use a 15% hydrogen peroxide concentration (Neighmond, 2017). The dental office home kits are 37.5% (15% / 40%) as effective as the dental office bleaching. The dental office home-kits (\$350) take two to four weeks and the trays are worn for one or two hours a day (Neighmond, 2017). The on-line do it yourself at-home bleaching trays (\$30) have a 15% hydrogen peroxide concentration and are 37.5% (15% / 40%) as effective as dental office bleaching. Because the dentist is supervising the procedure, a stronger bleaching solution can be used at the office than what's found in the home kits.

Whitening strips had the lowest expected cost at \$57.14, thus providing the most value followed by on-line do it yourself home bleaching tray kits (\$80), dental office bleaching (\$650) and then the dental office take home tray (\$933.33).

Teeth Straightening

Orthodontic Braces cost \$6,000, Invisalign clear aligners cost \$4,000 and the less expensive Smile Direct Club aligners cost \$2,000. The objective grading system passing rate for Invisalign was 27% lower than for orthodontic braces (Djeu, Shelton & Maganzini, 2005). The Smile Direct Club results can be just as effective as Invisalign, provided patients are eligible for Smile Direct Club.

Product	SR	Cost	Expected Cost
Smile Direct Club	73%	\$2,000	\$2,740
Invisalign Clear Aligners	73%	\$4,000	\$5,479
Orthodontic Braces	100%	\$6,000	\$6,000

Smile Direct Club had the lowest expected cost at \$2,740, thus providing the most value followed by Invisalign (\$5,479) and then orthodontic braces (\$6,000).

Dental Insurance

Dental plan health insurance averages around \$600 a year and covers the costs for annual routine care that includes twice a year cleanings (\$200) and x-rays (\$100), which would be valued at around \$300. A typical plan will also cover 70 to 80% of the costs for extractions, fillings, root canals (sometimes) and periodontal work and cover up to 50% the costs for major procedures such as crowns, bridges, inlays, dentures and sometimes implants. Dental insurance benefits often maxes out somewhere in in the range of \$1,000 - \$2,000 per year (Money Talks News, 2017). Some dental insurance with an annual premium may also have a deductible to pay before coverage kicks in. After the \$1,000 deductible has been met, insurance will pay a percentage of

the dental costs and then the coverage stops entirely once the patient reaches that maximum benefit amount.

A patient that goes to the dentist only twice a year for cleanings will likely save money by simply paying for the cleanings out of pocket (Podnos, 2016). In most cases dental insurance doesn't lower a person's overall dental costs since most with dental insurance underutilize it. The average person doesn't have need for regular dental services beyond one or two cleanings (\$100 - \$200) per year and an x-ray (\$100) every other year.

For decades, dentists urged all adults to schedule preventive visits every six months. However, recent evidence has found that annual cleanings, rather than bi-annual may be adequate for adults without certain risk factors for periodontal disease. Adults without apparent dental problems do not need dental x-rays every other year. The American Dental Association (2019) reported that adults who properly care for their teeth and have no symptoms of oral disease or cavities can goup to 3 years between bitewing x-rays rather than every other year. Panoramic dental x-rays are seldom needed so dentists should spare patients exposure when they can.

CONCLUSION

It was found that Smile Direct Club provided the most value when it comes to straightening teeth, root canals provided the most value in tooth decay, water fluoridation was the most effective reducing the prevalence of cavities and in most cases dental insurance doesn't lower an individual's overall dental costs.

It was found that hydrogen peroxide gel strips provided the most value for teeth whitening. A study into the concentrations of hydrogen peroxide gel whitening strips found that increased concentrations of hydrogen peroxide strips resulted in a greater whitening of teeth. The use of a 14% hydrogen peroxide strip displayed greater whitening results compared to the 6% hydrogen peroxide gel (Gerlach&Sagel, 2004).

This present study did not find a significant difference between the cost to prevent a cavity and the cost to fill a cavity. The expected cost to prevent a cavity by community fluoridated water was \$11 per year and the expected cost to prevent a cavity using fluoridated mouth rinse was \$16 per year, while the expected annual cost of an amalgam filling was \$16.24.

Although water fluoridation, amalgams, root canals, metal crowns, whitening strips, and smile direct club provide the most value, they are not always the most reliable treatments. Ceramic tooth fillings, veneers, dental office bleaching, and orthodontic braces were all more effective since they had higher success rates (SR). This study was conducted in order to find value mostly determined by dividing the cost by success rate or effectiveness. The findings do not necessarily

“A Comparative Expected Cost Analysis Study on Dental Services and Products Used in the United States”

determine what the best treatment should be for any individual consumer.

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“A Comparative Expected Cost Analysis Study on Dental Services and Products Used in the United States”

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