Published in final edited form as:
Acad Pediatr. 2024 July ; 24(5): 765–775. doi:10.1016/j.acap.2024.02.006.

A cost effectiveness analysis of population-level dental caries prevention strategies in US children

Cara B. Janusz, PhD[a,*], **Tran Doan, PhD**[a,b,c], **Acham Gebremariam, MS**[a], **Angela Rose, MS MPH**[a], **Martha Ann Keels, DDS PhD**[d,e], **Rocio B. Quinonez, DMD**[e], **George Eckert, MAS**[f], **Emily Yanca**[f], **Margherita Fontana, DDS PhD**[g,†], **Lisa A. Prosser, PhD**[a,b,*,†]

[a]Susan B. Meister Child Health and Evaluation Research (CHEAR) Center, Department of Pediatrics, University of Michigan, Ann Arbor MI

[b]Department of Health Management and Policy, School of Public Health, University of Michigan, Ann Arbor MI

[c]Department of Pediatrics, University of Pittsburgh School of Medicine, Pittsburgh PA (current)

[d]Department of Pediatrics, Duke University, Durham NC

[e]Division of Pediatric Dentistry and Public Health, University of North Carolina Adams School of Dentistry, Chapel Hill NC

[f]Department of Biostatistics and Health Data Science, Indiana University School of Medicine and Richard M. Fairbanks School of Public Health, Bloomington IN

[g]Department of Cariology, Restorative Sciences & Endodontics, School of Dentistry, University of Michigan, Ann Arbor MI

Abstract

Objective: To improve oral health disparities and outcomes among US children impacted by dental caries, there is a need to understand the cost-effectiveness of a targeted, risk-based versus universal-based approach for caries prevention.

Methods: Health and economic outcomes were simulated in a cohort of 50,000 US children aged 1–18 years, comparing current practice (CP) to risk-based-prevention (RBP) and prevention-for-all (PFA) strategies using healthcare sector and limited societal perspectives. Prevention included biannual oral health exams and fluoride varnish application, and one-time dental sealant placement. The primary outcome is the cost-effectiveness ratio (ICER), defined as the additional cost per quality-adjusted life year (QALY) gained when comparing each strategy to the next least costly one.

[*]**Corresponding author:** Cara Janusz, PhD, Department of Implementation Science, Wake Forest School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157, cjanusz@wakehealth.edu (*Present address*).
[†]Denotes equal contribution as senior author

Declarations of interest: None.

Results: For RBP compared to CP, the ICER was US$83,000/QALY from the healthcare sector perspective; for PFA compared to RBP the ICER was US$154,000/QALY. Using a limited societal perspective that includes caregiver time spent attending dental or medical setting visits, RBP compared to CP yielded a ratio of $119,000/QALY and PFA compared to RBP was $235,000/QALY. Results were most sensitive to changes in the probability of pain from an episode of dental caries, costs for prevention and restoration, and the loss in health-related quality of life due to dental caries pain. Scenario analyses evaluating a reduced intensity of prevention services yielded lower ICERs.

Conclusion: Using a risk-based approach that identifies and targets children at increased risk for dental caries to guide the delivery of prevention services represents an economic value similar to other pediatric prevention programs.

Keywords

cavities; prevention; oral health; economic evaluation; child health

Introduction

Dental caries disproportionately affects children from low income and minority families despite being a largely preventable condition.[1] Since the first US Surgeon General's report on oral health, the prevalence of dental caries among young children has declined from 28 to 23%, but important disparities in unmet need for prevention and treatment remain across sociodemographic groups. For example, dental caries prevalence among children aged 2–5 years from poor or near-poor families was ≥15% higher than children from non-poor families during 1999–2004 with minimal change in recent years.[2] Additionally, Mexican American and non-Hispanic Black early school aged children were almost twice as likely to have untreated cavities, during 2011–2016, compared to non-Hispanic white children.[2] To improve the country's oral health trajectory, there is a need to identify not only effective strategies for reducing dental caries but also efficient population-level approaches that address oral health disparities starting early in life.

The American Dental Association, the US Preventive Services Task Force, and the American Academy of Pediatrics have called for routine dental caries prevention to begin as early as age 1.[3–5] Yet, utilization remains low due to access barriers, a limited supply of Medicaid-accepting dentists, and other caregiver or family factors.[6,7] Indeed, fewer than a quarter of children attend a dental visit in the first year of life, according to recent data from the National Health and Nutrition Examination Survey.[8] Efforts to reimburse medical providers for oral preventive services to expand access have had mixed results.[9] And, according to a recent national survey, even though pediatricians reported providing anticipatory oral health counseling more consistently than in the past, less than half reported performing oral health screening exams and even fewer reported assessing caries risk in their patients despite three-quarters of respondents believing pediatricians should perform such tasks.[10]

Cost-effectiveness analysis is a tool often used to help decisionmakers understand the value of a given investment in a treatment or health program by measuring additional costs relative to the additional health benefit accrued. Previous economic evaluations have demonstrated the value of dental caries prevention using a single prevention intervention without risk stratification (e.g. fluoride varnish[11], pit-and-fissure dental sealants[12]). Using a caries risk assessment (CRA) to target prevention towards those at greatest risk of developing disease is potentially an efficient approach to improving oral health and reducing disparities in childhood in the context of scare healthcare resources. There are several CRA tools proposed for assessing a child's caries risk based on biological, behavioral, and social factors; however, few have been validated.[13] A recent NIH-funded project developed and initially validated a 10-item CRA questionnaire tool for use in children.[14,15] The objective of this study was to evaluate the cost-effectiveness of two population-level approaches for delivering the American Dental Association (ADA) recommended package of dental caries prevention to children[3–5], one approach using a CRA to target caries prevention, "risk-based prevention", and another approach scaling prevention to all children without using a CRA, "prevention-for-all", compared to current dental caries prevention practice in the US. [3–5]

Methods

Overall approach

A decision analytic model was developed to project dental caries costs and outcomes of three population-level strategies for dental caries prevention in a hypothetical cohort of 50,000 US children aged 1– 18 years. Costs and outcomes for each strategy were included from the healthcare sector perspective and from a limited societal perspective that added caregiver time costs.[16]

Strategies

Three strategies were modeled (1) *current practice*: prevention delivered *only* to the proportion of children receiving prevention according to best available data at the national-level (biannual fluoride varnish to 2%, one-time permanent molar sealants to 32% of children); (2) *risk-based prevention*: prevention delivered to 100% of children identified as high-risk for dental caries using a one-time CRA at age 1 year; and (3) *prevention-for-all:* prevention delivered to 100% of all children, regardless of risk status (Figure 1a). Following ADA recommendations[3–5], childhood caries prevention was defined as biannual fluoride varnish (FV) application to all primary and permanent teeth, and one-time dental sealant (DS) placement on first and second molars upon eruption. Children also received biannual oral health exams and dental caries restorative treatments at dentist visits when indicated. Dental visit utilization varied by strategy. The CRA applied as part of the risk-based prevention strategy is based on a CRA tool being tested and validated in a longitudinal prospective, multicenter cohort study of enrolled 1-year-old children.[14] The CRA questionnaire was designed for caregivers to self-report dental caries relevant risk-factors including social and biological disease determinants, indicators of the oral environment (e.g. diet), oral flora, personal hygiene and treatment factors in a medical setting.[15] A revised 10-item version of the CRA was recently shown to have good predictive accuracy of dental caries at age 4 years (AUC=0.73) which is similar to that of other more complex risk assessment approaches.[14]

Model structure and parameterization

Identical hypothetical cohorts were simulated for each of the three strategies, varying prevention utilization and corresponding treatment effectiveness by strategy (Figure 1a). The simulation model included a disease submodel to project tooth-level outcomes, and a cost submodel to aggregate costs and assign health outcomes at the mouth-level. In the disease submodel, outcomes were simulated using a state-transition model programmed in TreeAge Pro 2022 (Williamstown, MA). The simulations began at age 1 year and tracked health transitions in pairs of primary and then permanent teeth through age 18 years in 6-month cycles (Figure 1b).

Simulated tooth-level outcomes, including initial, moderate, and extensive caries lesions, and extractions and restoration procedures with and without sedation, were aggregated to create mouth-level outcomes and combined with costs and quality adjustments to project per child health effects, prevention costs, restoration costs, and overall costs in a cohort of 50,000 children. The aggregation and cost submodel was programmed in Stata V15 (College Station, TX).

Model inputs were derived using published and unpublished data, and expert panel opinion (Tables 1, S1a-d). For several parameters where limited or no data were available, input was obtained from an expert panel with subject matter expertise in pediatric dental caries prevention and treatment.

State-transition probabilities for caries progression—Longitudinal data from a caries risk study in children, the Predicting Caries Risk from Toddlers to the School-Age Years, in Primary Medical Settings trial[17,18], were used to define dental caries transition probabilities and risk status. Transition probabilities were defined for pairs of teeth that emerge together, using the prevalence of surface-level tooth data observed at approximate age 2.5 and 4 years. The proportion of children assigned to the high-risk strata for the simulated risk-based strategy was based on a CRA score of 5 or higher among children in the caries risk study. To project tooth-level transitions into adolescence, data from the caries risk study were calibrated to annualized prevalence data for moderate and extensive caries among children ages 1–18 years from the National Health and Nutrition Examination Survey.[8] The calibration specified transitions for primary teeth and permanent teeth, accounting for the natural history of tooth eruption and shedding.

For prevention strategy effectiveness, pooled caries prevented fractions (PF) were extracted from published metanalyses for each of the two primary prevention interventions: FV application to primary and permanent teeth[19], and DS application to permanent molars.[20] Then, using inputs derived from state- and national-level data[8], strategy-specific prevention effectiveness was derived by applying an adjustment to the PF for FV and DS to account for the proportion of the cohort assumed to receive prevention, e.g. for current practice, only 2% of children were applied treatment effectiveness for FV and 32% for DS.

Costs—Direct costs for preventive and restorative dental care and caregiver time costs (for the limited societal perspective) were included. Direct costs for dental care services (oral health exams, prevention interventions, caries restoration, tooth extraction) were calculated using the average reimbursement cited in the Medicaid fee schedules across 49 states and DC for the 2021–22 period (Table S1c). Costs for prevention strategies were derived by assigning direct costs to each service included in the defined bundle of services for each strategy. Costs of restoration or extraction were assigned by applying the same fee schedule to the number of events by procedure type (fillings, crowns, or extractions with and without sedation) projected using the state-transition model. Time costs for caregivers attending dental care visits with their child were estimated using input from the expert panel. All costs are reported in 2021 US$.

Quality of life adjustments—Moderate and extensive caries health states could lead to Health-related Quality of Life (HrQoL) loss for some proportion of children who experience pain related to the carious lesion.[21,22] Average Quality-Adjusted Life Year (QALY) loss associated with toothache pain was assumed to occur transiently, only during model cycles in which untreated moderate or extensive lesions had developed or persisted.

Outcomes

The primary outcome measure was the incremental cost-effectiveness ratio (ICER) expressed in US$ per QALY gained or per caries-months (number of months lived with moderate or extensive carious lesion(s)) averted. ICERs are commonly reported as the primary outcome for cost-effectiveness studies in health and medicine[16] because the measure provides a single comparative valuation of two or more rational, alternative uses of resources. ICERs are expressed as a ratio of incremental cost to incremental effect between the least costly/resource intense alternative to the next least costly one[23]. Disaggregated measures were also reported as secondary outcomes of the analysis, including total number of caries-months, total prevention costs, total restoration/extraction costs, and total QALYs per 50,000 cohort for each of the three prevention strategies. Costs and QALYs were discounted 3% annually.[24]

Uncertainty analysis

Parameter values were varied in one-way and multi-way sensitivity analysis using ranges for key parameter and parameter sets described in Tables 1 and S1a-d. Given incomplete data on caries prevention utilization in US children, scenario analyses were performed to evaluate alternative population-level uptake of prevention services for the current practice strategy. These “what-if” scenarios aimed to represent state-level variation in the proportion of children receiving biannual FV and one-time DS placements across the US (Table S1a). Time horizon (1–3.5, 1–9, and 1–13 years) and discount rate (0, 1.5%, 5%) were varied to assess sensitivity of results to time preferences. Other scenario analyses are described in Tables S3c.

Results

Health outcomes

Using base case assumptions, current practice yielded more than 3.2 million caries-months for the cohort of 50,000 children aged 1 year followed to age 18 years (Table 2). Compared to current practice, the risk-based prevention strategy averted 1.86 million caries-months and prevention-for-all strategy averted 2.74 million caries-months in the cohort over the same time horizon. For the hypothetical cohorts of 50,000 children, a cumulative gain of 1,030 QALYs was projected for risk-based prevention compared to current practice, and 435 QALYs was projected for prevention-for-all compared to risk-based prevention (Table 2).

Costs

Per 50,000 children from a healthcare sector perspective, the total costs were projected to be US$61 million for current practice, US$146 million for risk-based prevention, and US$213 million for prevention-for-all. Incremental costs of risk-based prevention compared to current practice were US$85 million. Incremental costs for prevention-for- all compared to risk-based prevention were US$67 million (Table 3). From a limited societal perspective, accounting for caregiver cost of time spent attending the dentist, the total costs per 50,000 children were US$98 million for current practice, US$220 million for risk-based prevention, and US$323 million for prevention-for-all. Incremental costs of risk-based compared to current practice were US$123 million and prevention-for-all compared to risk-based prevention were US$102 million (Table 2).

Incremental Cost-Effectiveness Ratios

For the base case, the ICER comparing risk-based prevention to current practice was US$83,000/QALY gained from a healthcare sector perspective. Comparing the prevention-for-all strategy to the risk-based strategy, the ICER was US$154,000/QALY gained from a healthcare sector perspective (Table 3). From the limited societal perspective, ICERs were higher at US$ 119,000/QALY gained for the risk-based strategy compared to current practice and US$ 235,000/QALY gained for the prevention-for-all strategy compared to risk-based (Table 3).

Sensitivity and scenario analyses

Sensitivity analyses explored the influence of plausible ranges for key related sets of parameters on the ICER. ICERs were most sensitive to changes in prevention and restoration costs, the probability of pain experienced with severe carious lesions, and less sensitive to others (Figures 2a & 2b). Varying the estimated pooled caries prevented fraction across a plausible range did not substantially change ICERs (Figures 2a & 2b). ICERs from the healthcare sector perspective remained below US$180,000 comparing risk-based prevention to current practice across all sensitivity analyses (Table S3).

In scenario analyses, reducing FV application and oral health exams from twice to once annually yielded more favorable ICERs (Table S3c). Increasing the propensity of high-risk children to develop a carious lesion, the ICER comparing prevention-for-all to risk-based prevention approached US$3 million/QALY gained whereas the ICER comparing the risk-based prevention strategy to current practice was reduced by 20% (Table S3c). In a scenario simulating 4 applications of FV per year for children identified as having a higher risk for developing dental caries, in accordance with the American Academy of Pediatric Dentistry (AAPD) 2023 best practices guidance[25], the ICER comparing risk-based prevention to current practice increased to US$130,000/QALY (Table S3c). Restricting the time horizon to fewer years (e.g. stopping the simulations prior to the cohort reached ages >13 years) substantially increased ICERs (Table S3c).

For the current practice strategy, we also evaluated scenarios assuming higher utilization of prevention interventions than the base case assumptions. For a moderate utilization scenario (23% of children receive FV and 50% DS), ICERs increased by roughly US$ 5,000–11,000/ QALY gained due to the projection of similar incremental costs as the base case comparisons between strategies but with fewer QALY gains (Table S3b). For the higher utilization scenarios (43% receive FV and 70% DS), ICERS were even higher, at an additional US$12,000–29,000/QALY gained than base case ICERs (Table S3b).

Discussion

This analysis evaluated the cost-effectiveness of targeting early prevention to children at increased risk for dental caries based on the use of a newly developed and initially validated CRA tool[14] for young children in medical settings versus a more universal prevention-for-all approach, compared to the current levels of dental caries prevention in the US. Both risk-based prevention and prevention-for-all strategies provided substantial health gains for children, reducing dental caries by 57% using the risk-based approach and a further 27% using the prevention-for-all strategy compared to current practice. But health gains also required net investment in dental caries prevention throughout childhood. Across a range of uncertainty analyses, the risk-based prevention approach using the CRA tool yielded more economically favorable ICERs than the prevention-for-all approach. Using base case assumptions from a healthcare sector perspective, the ICER for risk-based prevention was lower than willingness-to-pay thresholds commonly cited for the US setting (US$100–150,000/QALY)[26,27] at US$83,000/QALY, whereas the ICER for the prevention-for-all strategy slightly exceeded the upper threshold at US$153,000/QALY. Using a limited societal perspective, risk-based prevention and prevention-for-all strategies required slightly higher net investments with ICERS reaching US$119,000/QALY and US$235,000/QALY, respectively. The higher net investment required from the limited societal perspective is driven by the high time demands for caregivers accompanying their children when attending multiple oral health prevention visits per year for both prevention strategies. It is important to recognize that the acceptability of higher ICERs tends to increase with disease severity, which may not apply in the context of the typical dental caries episode.[28] Nonetheless, in the US, ICERs considered to be cost-effective for other primary child health prevention interventions, such as vaccines, are often within the range of US$100–150,000/QALY.[29]

Several studies have previously evaluated the cost-effectiveness of dental caries prevention in the US, including fluoride varnish application in young children, pit-and-fissure dental sealants in adolescence, and other variations of dental caries prevention and management interventions.[11,12,30,31] Only two studies reported outcomes that allow comparison with our results, using the cost per caries-month averted measure. One study[11] evaluated biannual fluoride varnish application during the well child visit schedule for children aged 9–42 months and another[12] evaluated a risk-based prevention strategy for dental sealant placement on permanent molars over a 10-year period. Both studies reported ICERs <US$10 per caries-month averted. Compared to these two studies, our ICERs were higher at US$46

per caries-month averted for risk-based prevention and US$76 per caries-month averted for prevention-for-all. However, there are important differences between these studies and ours, as our study included more comprehensive prevention. Namely, our study projected the cost of the recommended oral health exam schedule in addition to targeted dental caries prevention throughout childhood and adolescence. Our results still yield a favorable result for a risk-based strategy which is consistent with existing studies about the value of oral health prevention interventions.

One crucial assumption underlying the feasibility of risk-based prevention relates to the availability of a valid and easily scorable risk assessment to guide the delivery of dental caries prevention. Our base case analysis defined risk status (high risk = 47% of the cohort) based on data from an ongoing longitudinal trial among toddlers in the states of Indiana, Michigan, North Carolina and Iowa that developed a CRA tool for use in medical settings and assessed its predictive accuracy.[14,15] However, while this study is ongoing, there currently is a lack of standardized, easily implementable approaches to caries risk assessment in medical and dental care settings for children.[13,32] Once validated tools are widely available, our results show that the use of routine CRA to target children for dental caries prevention is cost-effective and more economically favorable than aiming to achieve strict adherence to prevention recommendations for all children, regardless of risk. This becomes even more evident if the risk of dental caries is higher than our base case assumption among the increased risk population strata. In a scenario analysis that increased the propensity of teeth to have carious lesions among increased risk strata, risk-based prevention was even more economically attractive whereas prevention-for-all was nearly US$3 million per QALY averted.

Our results were sensitive to several parameter inputs and assumptions. The number of visits and assigned procedures during the biannual oral health exam schedule were important drivers of overall costs. Reducing the intensity of prevention visits (oral health exams and fluoride varnish application) to once per year would improve the favorability of ICERs. In contrast, aligning the risk-based strategy with AAPD recommendations to apply FV 4 times per year to children who are screened as high risk for developing carious lesions, increased the ICERs for both risk-based and prevention-for-all strategies. In the US, only 40–70% of children, depending on age, attend the dentist biannually according to recent data from NHANES[8]. Considering access barriers and high time costs, a reduced intensity schedule might be a more appropriate real-world assumption. Costs were based on the mean reimbursement cited by state Medicaid fee schedules, using Delaware’s fee schedule as the upper and Michigan’s as the lower limit. The economic favorability of prevention became less attractive considering the costs cited in Delaware’s fee schedule, which is 60% higher than the mean reimbursement across states for the bundle of prevention services included in this analysis. Nonetheless, most states reimburse at rates closer to our base case. Only 1 out of every 10 state Medicaid programs that reimburse for the full package of prevention considered in our analysis cites a cost that exceeds the mean cost of prevention used in the base case by more than 20%. Our results were sensitive to shorter time horizons, which is consistent with other studies.[12] The cumulative health effects tracked from ages 1–18 years rationalize the cost of early adolescence oral health prevention like dental sealant application on second molars.

Limitations of our analysis relate to some parameters for which no or sparse data were available. Expert opinion was used to define practice patterns regarding restoration depending on age and disease progression for children. Additionally, time costs were defined using expert opinion and these costs may be higher for families who travel long distances to attend a dentist in low dental workforce supply areas[33] of the country. We also defined the caries prevention scenarios for current practice using a range of sources that do not necessarily represent a specific state context. Despite results not being highly sensitive to changes in these parameter values, future analyses representing the state-specific current practice compared to risk-based prevention that accounts for dental/medical workforce supply constraints would provide more precise information for state payers and policymakers. Finally, condition-specific health utilities for dental caries have not been measured and reported.[34] A quality-of-life measure proposed at the tooth level, the quality-adjusted tooth year, has previously been used in dentistry cost-effectiveness analyses.[35,36] However, this dental-utility measure was not used in the current analysis in order to facilitate comparisons with other child health prevention interventions, beyond oral health. Further empirical understanding about the experience of dental caries pain and the associated disutility is needed and should be prioritized for future research.

Conclusion

Our analysis underscores the importance and value of dental caries prevention, especially in early childhood and adolescence. In initial work to simulate a more real-world prevention perspective that focuses on oral health disparities, we demonstrated that using a caries risk assessment tool to guide the delivery of prevention interventions to the children at highest dental caries risk is economically attractive, when considering the incremental value of risk-based approaches and prevention-for-all to current practice in the US. Researchers, clinicians, and policymakers alike should evaluate the context-specific value and feasibility of leveraging care network partnerships between the medical and dental community to screen children for caries risk and optimize the delivery of prevent.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

We would like to acknowledge our expert panel for valuable feedback during the development of the model: Dr. Elisa Ghezzi, Dr. Stephen Ghezzi, Dr. Anderson Hara, Steven Levy, Dr. Barry Katz, Dr. James Boynton, and Dr. Amr Moursi. We also acknowledge Bridgid Cummings, Anton Avancena, Lauren Kimmel, Kerra Mercon, and Nadia Khan for their research assistance.

Funding/Support:

This work was supported by the National Institute of Health, National Institute of Dental and Craniofacial Research 2U01DE021412

References

1. Slade GD, Sanders AE. Two decades of persisting income-disparities in dental caries among U.S. children and adolescents. J Public Health Dent. Jun 2018;78(3):187–191. doi:10.1111/jphd.12261 [PubMed: 29243816]
2. Centers for Disease Control and Prevention. Oral Health Surveillance Report: Trends in Dental Caries and Sealants, Tooth Retention, and Edentulism, United States, 1999–2004 to 2011–2016. 2019.
3. Moyer VA, U. S. Preventive Services Task Force. Prevention of dental caries in children from birth through age 5 years: US Preventive Services Task Force recommendation statement. Pediatrics. Jun 2014;133(6):1102–11. doi:10.1542/peds.2014-0483 [PubMed: 24799546]
4. Wright JT, Crall JJ, Fontana M, et al. Evidence-based clinical practice guideline for the use of pit-and-fissure sealants: A report of the American Dental Association and the American Academy of Pediatric Dentistry. J Am Dent Assoc. Aug 2016;147(8):672–682.e12. doi:10.1016/j.adaj.2016.06.001 [PubMed: 27470525]
5. Weyant RJ, Tracy SL, Anselmo TT, et al. Topical fluoride for caries prevention: executive summary of the updated clinical recommendations and supporting systematic review. J Am Dent Assoc. Nov 2013;144(11):1279–91. doi:10.14219/jada.archive.2013.0057 [PubMed: 24177407]
6. Finlayson TL, Chuang E, Baek JD, Seidman R. Dental Service Utilization Among Children in the Child Welfare System. Matern Child Health J. May 2018;22(5):753–761. doi:10.1007/s10995-018-2444-y [PubMed: 29423585]
7. Simon L, Ahern J, Fox K, Barrow J, Palmer N. Variations in dental services by rurality among privately insured adults in the United States. J Public Health Dent. 2021;81(1):50–56. doi:10.1111/jphd.12398 [PubMed: 32918758]
8. Centers for Disease Control and Prevention. Data from: National Health and Nutrition Examination Survey (NHANES). 2015–2016.
9. Kranz AM, Preisser JS, Rozier RG. Effects of Physician-Based Preventive Oral Health Services on Dental Caries. Pediatrics. Jul 2015;136(1):107–14. doi:10.1542/peds.2014-2775 [PubMed: 26122805]
10. Lewis C, Quinonez R, Sisk B, et al. Incorporating Oral Health into Pediatric Practice: National Trends 2008, 2012, 2018. Acad Pediatr. 2022;22(8):1443–1451. doi:10.1016/j.acap.2022.06.008 [PubMed: 35732259]
11. Quiñonez RB, Stearns SC, Talekar BS, Rozier RG, Downs SM. Simulating cost-effectiveness of fluoride varnish during well-child visits for medicaid-enrolled children. Arch Pediatr Adolesc Med. 2006;160(2):164–70. doi:10.1001/archpediatrics.2012.797 [PubMed: 16461872]
12. Quinonez RB, Downs SM, Shugars D, Christensen J, Vann WF Jr., Assessing cost-effectiveness of sealant placement in children. J Public Health Dent. Spring 2005;65(2):82–9. doi:10.1111/j.1752-7325.2005.tb02791.x [PubMed: 15929545]
13. Cagetti MG, Bonta G, Cocco F, Lingstrom P, Strohmenger L, Campus G. Are standardized caries risk assessment models effective in assessing actual caries status and future caries increment? A systematic review. BMC Oral Health. Jul 16 2018;18(1):123. doi:10.1186/s12903-018-0585-4 [PubMed: 30012136]
14. Fontana M, Eckert GJ, Katz BP, et al. Predicting Dental Caries in Young Children in Primary Health Care Settings. J Dent Res. Jun 16 2023:220345231173585. doi:10.1177/00220345231173585
15. Fontana M, Eckert GJ, Keels MA, et al. Predicting Caries in Medical Settings: Risk Factors in Diverse Infant Groups. J Dent Res. Jan 2019;98(1):68–76. doi:10.1177/0022034518799080 [PubMed: 30205016]
16. Sanders GD, Neumann PJ, Basu A, et al. Recommendations for Conduct, Methodological Practices, and Reporting of Cost-effectiveness Analyses: Second Panel on Cost-Effectiveness in Health and Medicine. JAMA. Sep 13 2016;316(10):1093–103. doi:10.1001/jama.2016.12195 [PubMed: 27623463]

17. Fontana M, Eckert GJ, Keels MA, et al. Fluoride Use in Health Care Settings: Association with Children's Caries Risk. Adv Dent Res. Feb 2018;29(1):24–34. doi:10.1177/0022034517735297 [PubMed: 29355412]

18. Warren J, Levy SM, Xu Y. Tooth Eruption and Early Childhood Caries: A Multisite Longitudinal Study. Pediatr Dent. 2021;43(4):287–289. [PubMed: 34467845]

19. Marinho VC, Worthington HV, Walsh T, Clarkson JE. Fluoride varnishes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. Jul 11 2013;(7):Cd002279. doi:10.1002/14651858.CD002279.pub2

20. Ahovuo-Saloranta A, Forss H, Walsh T, Nordblad A, Mäkelä M, Worthington HV. Pit and fissure sealants for preventing dental decay in permanent teeth. Cochrane Database Syst Rev. Jul 31 2017;7(7):Cd001830. doi:10.1002/14651858.CD001830.pub5

21. Ghanei M, Arnrup K, Robertson A. Procedural pain in routine dental care for children: a part of the Swedish BITA study. Eur Arch Paediatr Dent. Oct 2018;19(5):365–372. doi:10.1007/s40368-018-0368-2 [PubMed: 30194611]

22. Low W, Tan S, Schwartz S. The effect of severe caries on the quality of life in young children. Pediatr Dent. Sep-Oct 1999;21(6):325–6. [PubMed: 10509332]

23. Neumann PJ, Sanders GD, Russell LB, Siegel JE, Ganiats TG. Cost-Effectiveness in Health and Medicine. Oxford University Press; 2016:537.

24. Attema AE, Brouwer WBF, Claxton K. Discounting in Economic Evaluations. Pharmacoeconomics. Jul 2018;36(7):745–758. doi:10.1007/s40273-018-0672-z [PubMed: 29779120]

25. American Academy of Pediatric Dentistry. Caries-risk assessment and management for infants, children, and adolescents. 2023:301–7. The reference Manual of Pediatric Dentistry.

26. Neumann PJ, Cohen JT, Weinstein MC. Updating Cost-Effectiveness — The Curious Resilience of the $50,000-per-QALY Threshold. New England Journal of Medicine. 2014;371(9):796–797. doi:10.1056/NEJMp1405158 [PubMed: 25162885]

27. Vanness D, Lomas J, Ahn H. A Health Opportunity Cost Threshold for Cost-Effectiveness Analysis in the United States. Annals of Internal Medicine. 2021;174(1):25–32. doi:10.7326/m20-1392/m33136426 [PubMed: 33136426]

28. Neumann PJ, Kim D. Cost-effectiveness thresholds used by study authors. JAMA. 2023;329(15):1312–1314. doi:10.1001/jama.2023.1792 [PubMed: 37071104]

29. Sullivan SM, Tsiplova K, Ungar WJ. A scoping review of pediatric economic evaluation 19802014: do trends over time reflect changing priorities in evaluation methods and childhood disease? Expert review of pharmacoeconomics & outcomes research. 2016;16(5):599–607. doi:10.1080/14737167.2016.1240618 [PubMed: 27659998]

30. Khouja T, Smith KJ. Cost-effectiveness analysis of two caries prevention methods in the first permanent molar in children. J Public Health Dent. Mar 2018;78(2):118–126. doi:10.1111/jphd.12246 [PubMed: 28833182]

31. Samnaliev M, Wijeratne R, Kwon EG, Ohiomoba H, Ng MW. Cost-effectiveness of a disease management program for early childhood caries. J Public Health Dent. Winter 2015;75(1):24–33. doi:10.1111/jphd.12067 [PubMed: 25040019]

32. Fontana M, Carrasco-Labra A, Spallek H, Eckert G, Katz B. Improving Caries Risk Prediction Modeling: A Call for Action. J Dent Res. Oct 2020;99(11):1215–1220. doi:10.1177/0022034520934808 [PubMed: 32600174]

33. Skillman SM, Doescher MP, Mouradian WE, Brunson DK. The challenge to delivering oral health services in rural America. J Public Health Dent. Jun 2010;70 Suppl 1:S49–57. doi:10.1111/j.1752-7325.2010.00178.x [PubMed: 20806475]

34. Vernazza CR, Birch S, Pitts NB. Reorienting Oral Health Services to Prevention: Economic Perspectives. J Dent Res. Jun 2021;100(6):576–582. doi:10.1177/0022034520986794 [PubMed: 33478327]

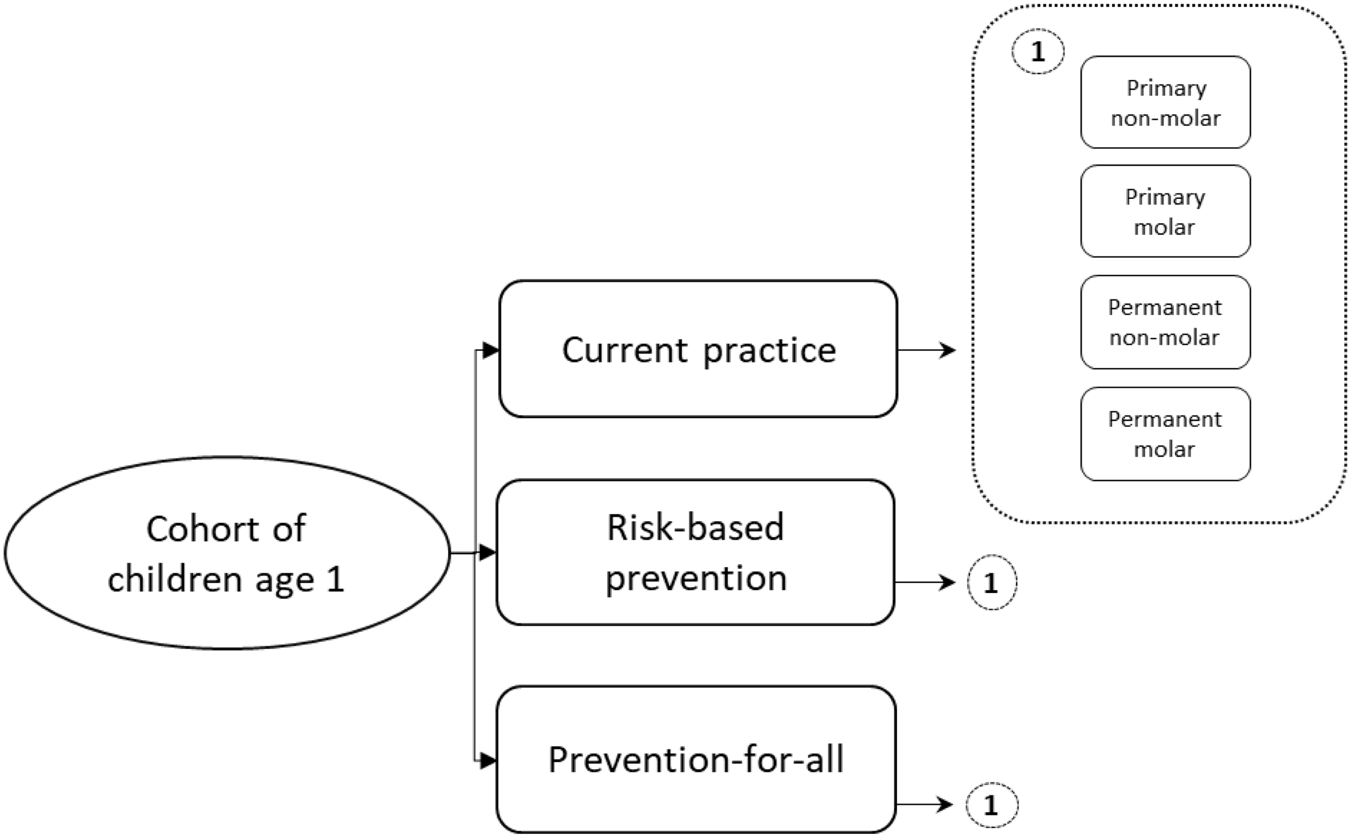
35. Fyffe HE, Kay EJ. Assessment of dental health state utilities. Community Dentistry and Oral Epidemiology. 1992;20(5):269–73. [PubMed: 1424546]

36. Bhuridej P, Kuthy RA, Flach SD, et al. Four-year cost-utility analyses of sealed and nonsealed first permanent molars in Iowa Medicaid-enrolled children. J Public Health Dent. Fall 2007;67(4):191–8. doi:10.1111/j.1752-7325.2007.00025.x [PubMed: 18087989]
37. Vargas CM, Macek MD, Goodman HS, Wagner ML. Dental pain in Maryland school children. J Public Health Dent. Winter 2005;65(1):3–6. doi:10.1111/j.1752-7325.2005.tb02780.x [PubMed: 15751489]
38. KFF. Monthly Child Enrollment in Medicaid and CHIP, 2018. Accessed July 1, 2023. https://www.kff.org/medicaid/state-indicator/total-medicaid-and-chip-child-enrollment/?currentTimeframe=12&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D
39. Lee HH, Faundez L, Yarbrough C, Lewis CW, LoSasso AT. Patterns in Pediatric Dental Surgery under General Anesthesia across 7 State Medicaid Programs. JDR Clin Trans Res. Oct 2020;5(4):358–365. doi:10.1177/2380084420906114 [PubMed: 32040927]
40. Coco AS. Cost-effectiveness analysis of treatment options for acute otitis media. Ann Fam Med. Jan-Feb 2007;5(1):29–38. doi:10.1370/afm.626 [PubMed: 17261862]
41. Dakin H, Petrou S, Haggard M, Benge S, Williamson I. Mapping analyses to estimate health utilities based on responses to the OM8–30 Otitis Media Questionnaire. Qual Life Res. Feb 2010;19(1):65–80. doi:10.1007/s11136-009-9558-z [PubMed: 19941078]
42. Oh PI, Maerov P, Pritchard D, Knowles SR, Einarson TR, Shear NH. A cost-utility analysis of second-line antibiotics in the treatment of acute otitis media in children. Clin Ther. Jan-Feb 1996;18(1):160–82. doi:10.1016/s0149-2918(96)80188-3 [PubMed: 8851461]

What's new

Use of fluoride varnish on all teeth and dental sealants on erupted molars are effective methods for preventing dental caries in children. However, cost-effectiveness evidence is limited regarding how to optimize targeting strategies for these interventions.

A. Modeled prevention strategies



B. Dental caries natural history simulation sub-model

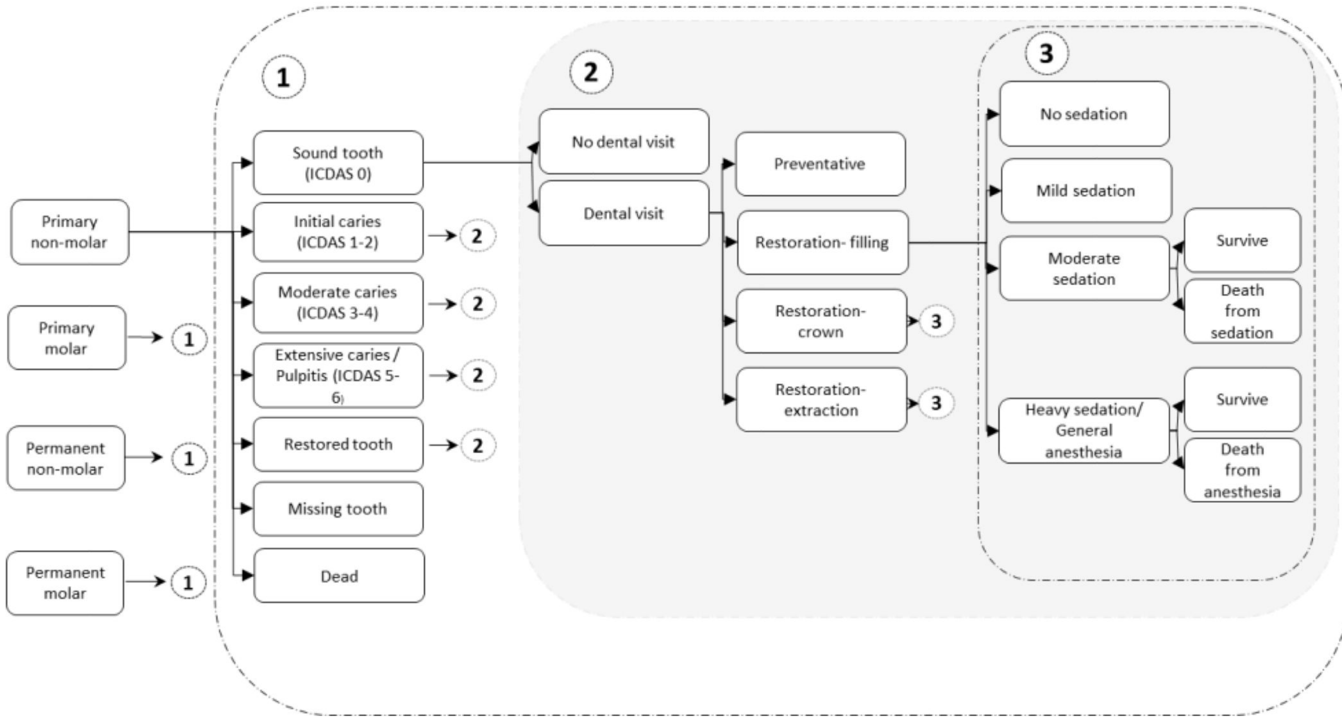
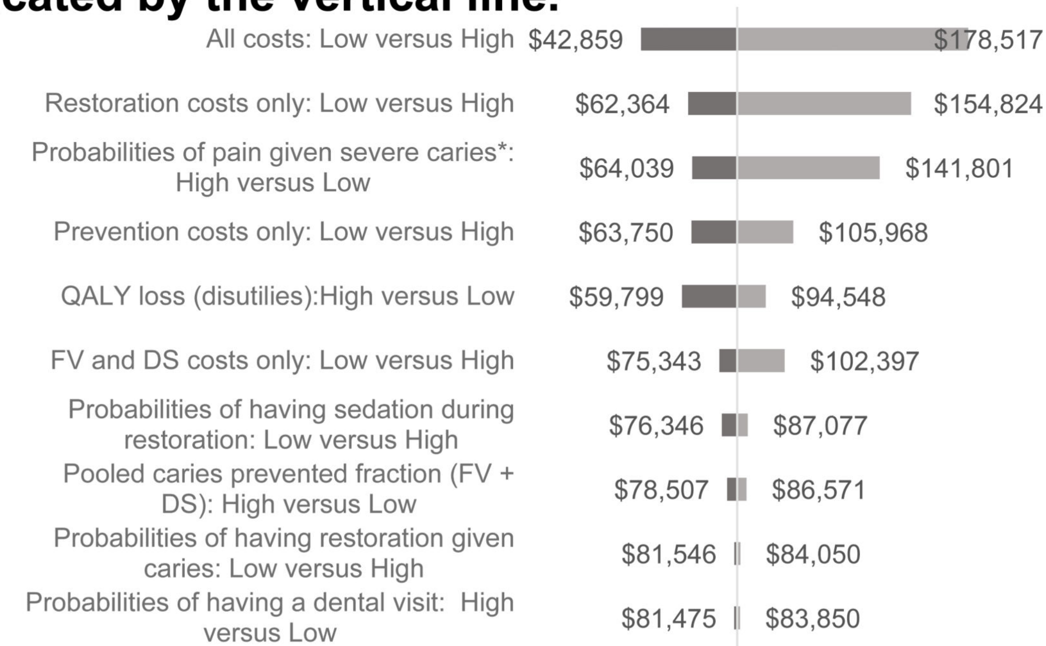


Figure 1.
Simplified schematic of dental caries prevention cost-effectiveness and health impact simulation model
Abbreviations: ICDAS = International Caries Detection And Assessment System

A. Sensitivity of ICERs to the range of values considered for key parameters for risk-based prevention compared to current practice among children ages 1-17 years, healthcare sector perspective. Base-case = $82,718/QALY gained, indicated by the vertical line.



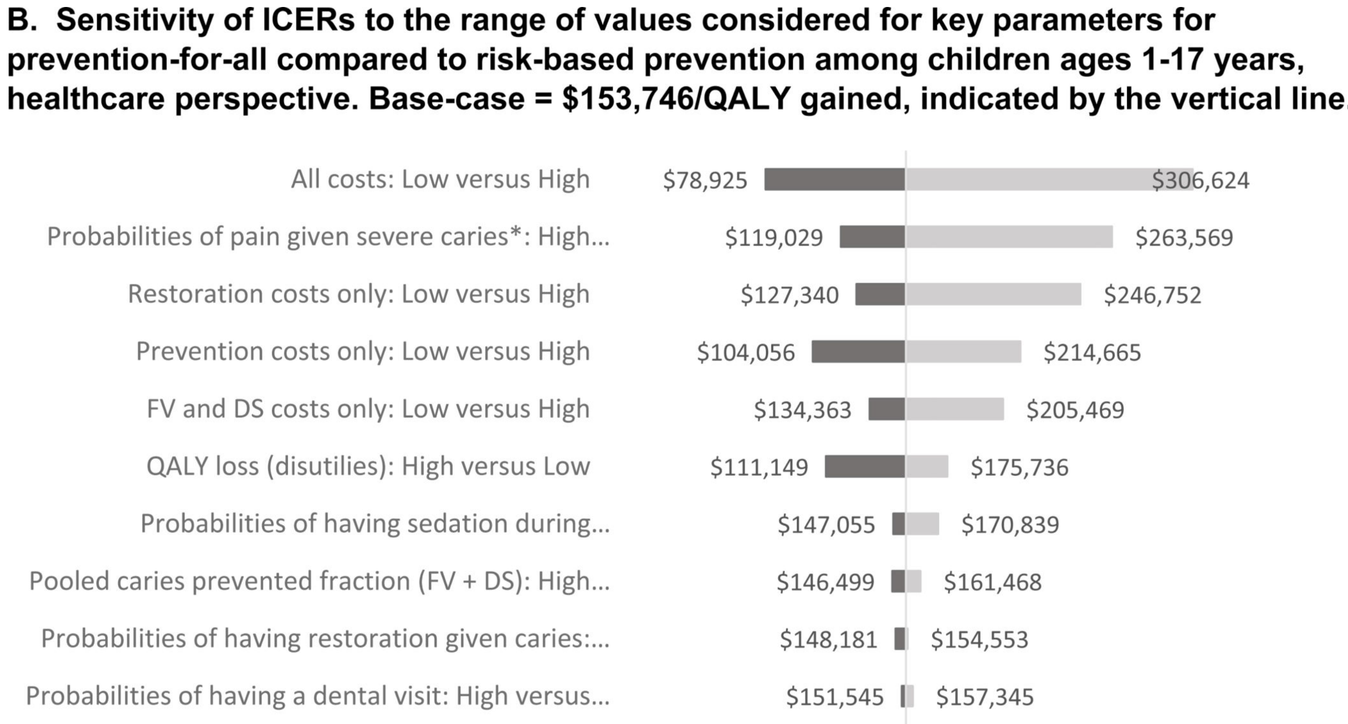


Figure 2.
One-way and multi-way sensitivity analysis

Table 1.

Selected probability, cost, and quality of life adjustment inputs for key model parameters[a]

Variable	Base case	Range for sensitivity analysis		Source
Probability of high-risk [b]	0.47	-	-	Fontana, unpublished
Prevalence of moderate/extensive caries, current practice [c]				
Age 1–3y	0.06	-	-	Fontana, unpublished, calibrated to NHANES 2015–16[8]
Age 4–6y	0.33	-	-	Fontana, unpublished, calibrated to NHANES 2015–16[8]
Age 7–9y	0.52	-	-	Fontana, unpublished, calibrated to NHANES 2015–16[8]
Age 10–13y	0.46	-	-	Fontana, unpublished, calibrated to NHANES 2015–16[8]
Age 14–17y	0.58	-	-	Fontana, unpublished, calibrated to NHANES 2015–16[8]
Probability of pain given moderate caries	0.24	0.14	0.31	Low et al. 1999[22], Expert opinion
Probability of pain given extensive caries	0.48	0.28	0.62	Low et al. 1999[22], Vargas et al. 2005[37] (LB), Ghanei et al. 2018[21] (UB)
Probability of dental visit, current practice				
Age 1–3y	0.37	0.30	0.43	NHANES 2015–16[8]
Age 4–6y	0.64	0.57	0.70	NHANES 2015–16[8]
Age 7–12y	0.70	0.64	0.75	NHANES 2015–16[8,21]
Age 13–17y	0.64	0.58	0.69	NHANES 2015–16[8]
Probability of receiving biannual fluoride varnish application, current practice	0.02	-	-	Michigan Medicaid, 2018[38]
Proportion receiving dental sealant placements, current practice [d]	0.32	-	-	NHANES 2015–16[8]
Probability of restoration for moderate/extensive caries given dental visit [e]				
Age 1–3y	0.9	0.75	1	Expert opinion
Age 4–6y	0.95	0.75	1	Expert opinion
Age 7–12y	1	0.75	1	Expert opinion
Age 13–17y	1	0.75	1	Expert opinion
Probability of heavy sedation/GA given restoration for moderate/extensive caries **				
Age 1–3y	0.16	0.06	0.25	Lee et al. 2020[39]
Age 4–6y	0.09	0	0.14	Lee et al. 2020[39]
Age 7–12y	0.02	0	0.09	Lee et al. 2020[39]
Age 13–17y	0.01	0	0.1	Lee et al. 2020[39]
Pooled caries prevented fraction of dental sealant placement, annual				
1st and 2nd permanent molars (ages 7 and 13)	0.88	0.81	0.92	Ahovuo-Soloranto et al. 2017[20]
Pooled caries prevented fraction of fluoride varnish application, annual				
Primary teeth	0.37	0.24	0.51	Marinho et al. 2013[19]
Permanent teeth	0.43	0.3	0.57	Marinho et al. 2013[19]

Variable	Base case	Range for sensitivity analysis		Source
Caries risk assessment cost, one time [f]	$16.04	$4.95	$25.15	State Medicaid Fee Schedules, 2021–22[g]
Oral health exam costs, annual[f, g, h]				
Age 1–2y	$72.66	$29.78	$108.58	State Medicaid Fee Schedules, 2021–22[g]
Age 3–6y	$174.69	$90.46	$289.29	State Medicaid Fee Schedules, 2021–22[g]
Age 7–12y	$156.01	$85.04	$254.68	State Medicaid Fee Schedules, 2021–22[g]
Age 13–17y	$187.85	$105.79	$303.07	State Medicaid Fee Schedules, 2021–22[g]
Fluoride varnish application cost, every 6 months[f]	$20.88	$9.00	$33.55	State Medicaid Fee Schedules, 2021–22[g]
Dental sealant placement cost, per molar, one time[f]	$28.76	$15.12	$45.14	State Medicaid Fee Schedules, 2021–22[g]
Restoration costs, average per procedure[f,i]	$128.22	$73.85	$290.56	
Heavy/GA sedation costs, per procedure [f]				
Hospital setting	$2,777.44	$1,800	$8,368	Lee et al. 2020[39], State Medicaid Fee Schedules, 2021–2022
QALY loss related to pain associated with moderate or extensive caries, per cycle	0.0085	0.0049	0.0112	Coco 2007[40], Dakin 2010[41], Oh 1996[42]; Expert Opinion

Abbreviations: UB= upper bound; LB= lower bound, GA=General Anesthesia QALY=Quality-adjusted Life Year

[a] Additional input parameter details are available Table S1 in the technical appendix, where cycle length conversion to 6-months for all probabilities and costs is described.

[b] The proportion of children assessed as high-risk for developing caries was based on a score of 5 or higher with the CRA being tested and validated in the longitudinal caries risk study described in Fontana et al 2023.

[c] Prevalence estimates for older age groups were derived by calibrating tooth-level disease prevalence data observed at 2.5 and 4 years in the Predicting Caries Risk from Toddlers to the School-Age Years, in Primary Medical Settings trial (Fontana et al) to NHANES 2015–16 age-specific caries prevalence data.

[d] All three strategies modelled dental sealant placement occurring upon eruption of primary and secondary molars and were assumed to stay in place for the duration of the time horizon. Current practice was defined by estimating the proportion of children aged 6–17 years with at least one molar recorded as sealed in NHANES 2015–16 dentition exam data.

[e] Additional probabilities of restoration given initial caries available in Table S1.

[**] Probabilities for other non-GA types of sedation given restoration are described in Table S1.

[f] All costs are in 2021 US dollars.

[g] Complete citations for the 48 state fee schedules that were consulted are available in the Technical Appendix.

[h] Oral health exam costs in this table represent mean cost for age-strata; 6-month costs are described in Table S1.

[i] Restoration procedures tracked and costed in the model included: fillings, crowns, and extractions.

Table 2.

Projected total and incremental costs and health events per 50,000 children aged 1–17 years, discounted, US$2021.

Strategy	Total costs (in thsnd)		Prevention costs (in thsnd)		Restoration costs (in thsnd)		Incremental total costs (in thsnd)		Total caries-months (in thsnd)	Caries-months averted (in thsnd)	QALYs lost	Incr. QALYs gained
	No time costs[±]	Time costs	No time costs	Time costs	No time costs	Time costs	Healthcare sector	Limited societal[§]				
Current practice	$61,248	$36,983	$49,807	$34,164	$11,441	$2,819	-	-	3,235	-	1,913	-
Risk-based prevention[§]	$146,426	$74,557	$89,046	$61,380	$56,578	$13,176	$85,178	$122,751	1,376	1,859	883	1,030
Prevention-for-all	$213,322	$109,879	$132,478	$91,399	$80,844	$18,480	$66,897	$102,219	500	876	448	435

[§] The projected costs and number of events for the risk-based prevention strategy is based on 47% of the cohort receiving risk-based prevention and 53% of the cohort receiving current practice

[±] Total costs for the risk based strategy also include the cost of the one-time caries risk assessment, in addition to prevention costs and restoration costs.

Abbreviations: thsnd = thousands; incr = incremental; QALYs=Quality-adjusted Life Years

[§] Limited societal perspective includes time costs.

Table 3.

Incremental cost-effectiveness ratios (ICERs) comparing risk-based prevention to current practice and prevention-for-all to risk-based prevention among children aged 1−17 years, discounted, US$2021.

	Healthcare sector perspective		Limited societal perspective[§]	
Strategy	**$/QALY gained**	**$/caries-month averted**	**$/QALY gained**	**$/caries-month averted**
Current practice	-	-	-	-
Risk-based prevention	$82,718	$45.81	$119,206	$66.02
Prevention-for-all	$153,746	$76.37	$234,927	$116.70

[§] Limited societal perspective includes time costs