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COVID-19 Pandemic Impact on US Childhood Caries and Potential Mitigation

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Abstract

Non-Hispanic Black (NHB) and Hispanic and low-income US children have a higher prevalence of untreated caries than their higher-income and non-Hispanic White (NHW) counterparts. Due to the COVID-19 pandemic, many dental offices and school sealant programs closed beginning March 2020. We examine the effect of reduced access to restorative care and sealants on the oral health of children from low-income households overall and by race/ethnicity and how increased sealant delivery in September 2022 could mitigate these effects. We used Markov chain Monte Carlo simulation to model COVID-19's impact on first permanent molar (1M) caries incidence and loss in quality of life (disability-adjusted life years [DALYs]) due to time lived with 1M untreated caries. Our model followed a cohort of children aged 7 y in March 2020 until February 2024. Model inputs were primarily obtained from published studies and nationally representative data. Excess DALYs per 1,000 children attributable to reduced access to care during the pandemic were 1.48 overall and greater for Hispanic (2.07) and NHB (1.75) children than for NHW children (0.94). Excess incidence of 1M caries over 4 y was 2.28 percentage points overall and greater for Hispanic (2.63) and NHB (2.40) children than for NHW (1.96) children. Delivering sealants to 50% of eligible 1Ms in September 2022 would not completely mitigate COVID-19's health access impact: overall excess DALYs would decrease to 1.05, and absolute disparities in excess DALYs between NHW children and Hispanic and NHB children would remain but decrease by 0.38 and 0.33, respectively. Sealing 40% of eligible 1Ms, however, would bring overall 4-y caries

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Author Contributions

C. Scherrer, contributed to conception, design, data analysis, and interpretation, drafted and critically revised the manuscript; S. Naavaal, M. Lin, S.O. Griffin, contributed to conception, design, data acquisition, analysis, and interpretation, drafted and critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

Declaration of Conflicting Interests

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incidence down to pre–COVID-19 levels and eliminate the differential effect of the pandemic on children from minority groups. The pandemic’s negative impact on the oral health of children from low-income households and increased disparities could be partially mitigated with increased sealant delivery.

Keywords

dental caries; quality of life; dental sealants; health status disparities; Monte Carlo method; DALYs

Introduction

Globally, untreated dental caries in permanent dentition is the most prevalent condition monitored by the Global Burden of Disease (Kassebaum et al. 2017), disproportionately affecting the poor and socially disadvantaged (Peres et al. 2019). In the United States, notable disparities exist between racial/ethnic minority and non-Hispanic White (NHW) children (Centers for Disease Control and Prevention [CDC] 2019). Untreated caries can cause pain, infection, and poor diet/nutrition and limit social interaction and learning (US Department of Health and Human Services 2000). In 2008, nearly 34 million school hours were lost among US children because of urgent dental needs, largely due to sequelae of dental caries (Naavaal et al. 2017; Naavaal and Kelekar 2018).

Dental sealants are highly effective in preventing dental caries and are recommended by the American Dental Association (Wright et al. 2016). However, many low-income and racial/ethnic minority US children do not routinely visit the dentist (Medical Expenditure Panel Survey [MEPS] 2018). Furthermore, among low-income children visiting the dentist, non-Hispanic Black (NHB) children are less likely to receive dental sealants or topical fluoride than NHW children (Wei et al. 2018). School sealant programs (SSPs) are recommended by the Community Preventive Services Task Force as an effective way to increase receipt of dental sealants and reduce disparities in sealant prevalence by income (Community Preventive Services Task Force 2016).

Because of COVID-19, many dental offices and SSPs closed beginning in March 2020 and as of May 2021 have yet to return to full capacity, thus reducing access to sealants and restorative dental services (Health Policy Institute 2021). The aims of this study were twofold: 1) to estimate the impact of reduced delivery of sealants and restorative care during COVID-19 on caries incidence in first permanent molars (1Ms) and resulting loss in quality of life among low-income US children (household income <200% of federal poverty level) overall and by race and ethnicity (i.e., Hispanic origin) and 2) to examine how increased sealant delivery could mitigate these negative outcomes.

Methods

To model the impact of reduced delivery of sealants and restorative care during COVID-19, we used a simulation model with 48-mo time horizon—from the start of the pandemic, March 1, 2020, to February 28, 2024. We chose 48 mo because few studies have evaluated

the effectiveness of sealants in preventing caries beyond this period (Ahovuo-Saloranta et al. 2017). We assumed that the monthly probability that a 1M developed a cavity (known as attack rate [AR]) was constant across all 1Ms in the same mouth and over time (Quinonez et al. 2005). We thus conducted the analysis at the 1M level.

Model

Our model (Fig. 1) followed a cohort of children ($n = 1,000$) aged 7 y and in first or second grade at model initiation (March 1, 2020). To estimate receipt of sealants on 1Ms through SSPs among children from low-income households (SSPsealant), we assumed that school children eligible for the free or reduced-price lunch program were a proxy for children from low-income households and that SSPs delivered sealants during the school year (September to May) to second graders attending high-need schools (50% students eligible for free/reduced-price lunch; Association of State and Territorial Dental Directors 2020). Among children with a dental visit (DV), we assumed that receipt of sealants on 1Ms only occurred for children aged 6 to 9 y (DVsealant). This assumption is consistent with national estimates of the proportion of 1Ms with sealants by age (Appendix Table 1) and the Medicaid measure that reports sealant placement on 1Ms (Centers for Medicare and Medicaid Services 2021). The probability that 1Ms received sealants (sealed) equaled SSPsealant plus DV multiplied by DVsealant.

At initiation, 1Ms could be in 1 of 4 states: sealed (S), not sealed with no caries (NSNC; i.e., with no untreated or restored/filled caries), not sealed with untreated caries (NSC), and restored/filled (F). During each month of the simulation, 1Ms could remain in the same state or, if not in F, transition to a different state. We assumed the following monthly transition probabilities for each state:

- All 1Ms in S were sound and could 1) remain in S with the probability that the sealant was retained (R_i where i represents age of sealant in months) or 2) transition to NSNC with probability $(1 - R_i)$.
- 1Ms in NSNC could 1) stay in that state if they remained sound and unsealed $(1 - AR)$ multiplied by $(1 - \text{sealed})$, 2) transition to S if they remained sound and were sealed $(1 - AR)$ multiplied by sealed, or 3) transition to NSC with probability AR.
- 1Ms in NSC could 1) remain in NSC if the child did not visit the dentist $(1 - DV)$ or 2) move to F with probability DV. We assumed that all NSC 1Ms were filled during a DV.
- 1Ms, once in F, did not transition to other states.

Model Parameters

The value, distribution, and data source of all parameters are provided in Table 1.

Data Sources

Parameters were derived from published data: the 2011–2016 National Health and Nutrition Examination Survey (NHANES) and the Household Component of the 2015–2018

MEPS. The NHANES and MEPS are complex multistage probability samples of the US population. Further information on the NHANES is available at <http://www.cdc.gov/nchs/nhanes.htm> and the MEPS at https://meps.ahrq.gov/survey_comp/hc_data_collection.jsp. In our analyses, we used population weights to generate nationally representative estimates for children from low-income households overall and by race/ethnicity (NHW, NHB, and Hispanic).

Parameter Values

Model Initialization.—To estimate the initial probability that a 1M was in each state, we used NHANES data for children aged 6 y with 4 erupted 1Ms. Because we did not have a sufficient sample size to stratify 1M state data for children aged 6 y by race/ethnicity, we used data by race/ethnicity for children aged 6 to 11 y in aggregate to adjust the overall probability upward or downward for each race/ethnicity at age 6 y (Appendix Table 2). The probability that 1Ms were in the NSNC state equaled $1 - (\text{NSC} + \text{S} + \text{F})$.

Transition Probabilities.—We used NHANES data and a previously published methodology that averages the annual AR across ages 7 to 12 y to estimate the overall annual AR (Griffin et al. 2014). Calculations of AR are provided in Appendix Table 3.

We used MEPS data to estimate annual DV overall and by race/ethnicity. We used aggregated data for children aged 6 to 11 y because DV did not appear to vary greatly by year of age (Appendix Table 4).

To estimate SSPsealant, we used data on the number of high-need schools and children eligible for free or reduced price lunch (National Center for Education Statistics n.d.) combined with the percentage of high-need schools served by SSPs (The Pew Charitable Trusts 2015) and the average number of children per served school, as estimated with data from 16 states funded by the CDC for SSPs and the Synopses of State Dental Public Health Programs (Association of State and Territorial Dental Directors 2020). Details are provided in Appendix Figure 1. We assumed that SSPsealant did not vary by race/ethnicity (CDC 2001).

To estimate the annual probability that 1Ms received sealants from a dental office (DVsealant), we first used NHANES data to estimate the proportion of sealed 1Ms among children aged 6 y with all 1Ms erupted at model initiation (0.179). We next iteratively solved for this probability based on model assumptions and all other parameter values, including SSPsealant, such that the proportion of 1Ms in the sealed state at 48 mo was 0.391 (proportion in sealed state for children aged 9 and 10 y; Appendix Table 5). We adjusted this value upward or downward for each race/ethnicity with an adjustment factor calculated with sealant prevalence data for children aged 6 to 11 y using the same methodology as for the initial tooth states (Appendix Table 2; Wei et al. 2018).

We assumed that sealant effectiveness was directly measured by retention (Ahovuo-Saloranta et al. 2017). Monthly sealant loss ($1 - R_j$) was estimated with a formula from a published article (Quinonez et al. 2005), $0.01 \times e^{(-0.012 * M_j)}$, where M_j equals months in state S.

Parameter values that varied due to the delayed care and health debt of the COVID-19 pandemic, hereafter referred to as “COVID-19 attributable,” were SSPsealant and DV, which affected DVsealant. For the COVID-19 model, we assumed the following. 1) Dental utilization (preventive and restorative) varied by month (DV_i where i represents month), and the effect of COVID-19 was greatest in the first 2 mo and then diminished during each successive month—first steeply and then more moderately (Health Policy Institute 2021; Appendix Fig. 2). 2) IMs among second graders did not receive sealants from SSPs from March 2020 to August 2020 but then received them at an increasing linear rate of 0 in August 2020 to 25% of the pre-COVID-19 level in February 2021. This latter assumption was based on data from 16 states funded by the CDC for SSPs that indicated a 75% median reduction in SSP activity in spring 2021 relative to pre-COVID-19 levels.

Simulation and Outcomes

We used a Markov chain Monte Carlo simulation (1,000 replications for 4,000 IMs) for all children and separately for Hispanic, NHB, and NHW children, allowing parameters to vary simultaneously according to their distribution (Table 1). For each replication, we calculated outcomes for the COVID-19 and “no COVID-19” scenarios and the difference between them (excess outcomes attributable to the COVID-19 pandemic). Calculations are detailed in Appendix Table 6. Loss in quality of life over 4 y (measured by disability-adjusted life years [DALYs] per 1,000 children; Salomon et al. 2015) attributable to time lived with untreated caries and associated disutility was derived from total IM months in NSC. Because DALYs are measured at the child level, we divided the tooth-level value by the average number of decayed teeth per child with at least 1 decayed tooth for each race/ethnicity (CDC 2019), to obtain a child-level value and then multiplied this by the disability weight (annual loss in health due to untreated caries). IM caries incidence over 4 y was derived from the number of IMs in NSNC or S at baseline that transitioned to NSC at some point during the 4 y. IM sealant delivery over 4 y was derived from the number of IMs that transitioned to S. Untreated caries prevalence among IMs at the end of year 3 was derived from the number of IMs in all states at model initiation and those in NSC at year 3. Year 3 was chosen for this measure to model what is soon (February 2023) to be the extra unmet need for dental care in the system. The mean, standard error, and P value across the 1,000 replications were estimated for each outcome. All reported values are significant at $P < 0.01$.

To identify the most influential variables on excess DALYs and excess caries incidence, we conducted a deterministic sensitivity analysis (Fig. 2). In this analysis, we allowed each variable to deviate $\pm 20\%$ from its mean value while holding all other variables constant at their mean value. Finally, we simulated the effect of increased sealant delivery to IMs in the NSNC state during month 30 of the model in reducing DALYs and caries incidence attributable to the pandemic.

Simulation findings were scaled to the number of low-income second graders overall and for each race/ethnicity (National Center for Education Statistics n.d.). We determined the number of children in each race/ethnicity group by multiplying the overall estimate by the percentage of children from low-income households aged 6 to 11 y from the 2011–2016

NHANES who were NHW, NHB, and Hispanic. These values were multiplied by 4 to obtain number of IMs.

Results

Excess/Deficit Outcomes Attributable to COVID-19

Overall DALYS per 1,000 children over 48 mo without and with the COVID-19 pandemic's impact on dental care were 4.97 and 6.45, respectively (Table 2). The excess DALYS attributable to COVID-19 were thus 1.48 per 1,000 children and 2,924 when applied to all children ($n = 1,975,550$; Table 1). Excess DALYS per 1,000 children for Hispanic (2.07) and NHB (1.75) children were about twice that for NHW children (0.94). Similarly, estimated total excess DALYS were 707 for all NHW children ($n = 744,059$), 1,376 for Hispanic children ($n = 664,865$), and 713 for NHB children ($n = 407,440$).

COVID-19-attributable excess incidence of 1M caries over 4 y was 2.28 percentage points (PP): 15.48% without and 17.77% with COVID-19. Again, the excess incidence was significantly higher for Hispanic (2.63 PP) and NHB (2.40 PP) children than for NHW children (1.96 PP).

The deficit in 1M sealants delivered overall was 12.94 PP: 31.71% without and 18.78% with COVID-19. The deficit was 13.30 PP for NHW, 12.96 PP for Hispanic, and 12.33 PP for NHB.

Overall untreated caries prevalence among 1Ms at the end of year 3 was 6.00% without COVID-19 and 7.93% with COVID-19, resulting in attributable excess prevalence of 1.93 PP. Excess values for NHW, Hispanic, and NHB children were, respectively, 1.63, 2.20, and 2.17 PP, with excess prevalence among Hispanic and NHB children being higher than that for NHW.

Tornado Plot

When all parameters were set at their mean values and not allowed to vary, excess DALYS attributable to the impact of the COVID-19 pandemic were 1.28 (SE = 0.04; Fig. 2). The tornado plot indicates that the parameter with the largest influence on excess DALYS was the fraction of DV capacity available during COVID-19. Changing this value by 20% resulted in an approximately 40% change in excess DALYS. A unitary change in the disability weight (20%) resulted in a corresponding unitary change in excess DALYS (20%), as expected. The impact of all other factors on DALYS was less than unitary.

Increasing Sealant Delivery in Month 30 as a Mitigation Strategy

Under the COVID-19 scenario, we estimated the percentage of 1Ms in NSNC (i.e., eligible for sealants) at month 30 to be 59.0%. We examined the effect of sealant delivery to 10% to 50% of these eligible 1Ms in month 30 on excess DALYS and caries incidence by the end of month 48. Month 30 was chosen as a reasonable time for significant intervention to occur (September 2022). Sealing an additional 50% of eligible 1Ms did not completely mitigate the effect of COVID-19 on excess DALYS. Overall excess DALYS ranged from 1.51 if no additional sealants were delivered to 1.05 if 50% of eligible 1Ms were sealed

(data not shown). Due to the number of DALYs that had already accumulated at that point, even delivering sealants to all eligible 1Ms in month 30 would not bring the level of DALYs back to the level without the COVID-19 pandemic by month 48. Figure 3 shows the mitigation impact for Hispanic, NHW, and NHB separately. Although increased sealant delivery decreased absolute disparities in DALYs by race/ethnicity, disparities persisted even when 50% of eligible 1Ms were sealed. The disparity in excess DALYs per 1,000 children between Hispanic and NHW decreased by 0.38 (from 1.15 to 0.77), and the disparity between NHB and NHW decreased by 0.33 (from 0.81 to 0.48).

Our model, however, did predict that sealing approximately an additional 40% of eligible 1Ms in month 30 would bring 4-y caries incidence down to pre-COVID-19 levels. Dental offices and SSPs would have to seal about an additional 40% of 1Ms among NHB and 48% of 1Ms among NHW or Hispanic children to lower incidence to pre-COVID-19 levels (Fig. 3). Disparities in excess caries incidence between NHW and NHB children would be eliminated if in both groups an estimated additional 25% of 1Ms were sealed; disparities between NHW and Hispanic children would be eliminated if approximately 40% of eligible 1Ms were sealed.

Discussion

We found that the reduction in DVs and SSPs due to the COVID-19 pandemic had a negative impact on the oral health of low-income US children and that the impact disproportionately affected children from minority groups. Our estimates had low uncertainty: the standard error was small relative to the mean. For example, estimated 4-y excess DALYs attributable to the COVID-19 pandemic per 1,000 children were 1.48 with a 95% CI of 1.34 to 1.62. The excess DALYs of 1.48 mean that excess untreated caries was equivalent to a loss of 1.48 y of full health across 1,000 children over 4 y. These findings were also robust to variation in parameter values. Except for the parameter COVID-19-attributable reduction in DV, the percentage change in excess DALYs due to varying the parameter value was equal to or less than the percentage change in the parameter. Conservatively, impact was measured only for 48 mo.

Disparities in caries and untreated caries between minority children and NHW children aged 6 to 11 y were present prior to COVID-19: prevalence was about twice as high among Hispanic and NHB children than among NHW children (CDC 2019). Our findings suggest that disparities by race/ethnicity among children from low-income households likely increased with the pandemic. Estimated excess DALYs among NHB and Hispanic children were about twice those among NHW children. Indeed except for sealant delivery, all other COVID-19-attributable excess outcomes were significantly higher among children from minority groups.

Our estimates, however, indicate that applying sealants soon to 25% to 50% of eligible 1Ms could significantly reduce disparities in excess DALYs and eliminate them for excess 4-y caries incidence. This mitigation could be through additional SSPs or increased dental capacity. With DALYs accumulating since March 2020, the COVID-19 pandemic has affected quality of life that cannot be erased quickly or completely. Yet, there were

significant benefits from the modeled mitigation, reducing DALYs significantly and bringing the 4-y caries incidence down to estimates of what the levels would have been without COVID-19 at the 40% application rate.

Untreated caries affects children's well-being (GBD 2017 Oral Disorders Collaborators et al. 2020) with spillover effects into learning. A recent meta-analysis noted that the odds of school absenteeism were 43% higher among students with poor oral health than those without poor oral health (Ruff et al. 2019). Poor oral health can also affect grades. A 2018 meta-analysis revealed that children with untreated decay had 40% higher odds of poor school performance than children with no decay (Rebelo et al. 2019). Similarly, a meta-analysis from 2019 reported that poor oral health increased the odds of poor academic performance by 52% (Ruff et al. 2019). This highlights the importance of implementing mitigation strategies soon.

This study has certain limitations. First, we captured the impact on oral health from reduced access to sealants and fillings. Not capturing the reduction in other preventive care, such as fluoride varnish application, likely makes these estimates of negative impact due to the reduction in dental care during the COVID-19 pandemic less extreme than actual. We also measured sealant effectiveness by retention, which may be true only for resin-based materials. Some studies suggest that glass-ionomer has similar effectiveness as resin-based sealants (Wright et al. 2016). Therefore, not capturing the retention for other sealant materials may have had a minimal impact on our estimates. In addition, some model parameters, such as COVID-19 impact on DVs and SSP capacity, had to be estimated from the available data and projected for later months of the 4-y horizon. However, in general, model parameters were estimated conservatively, and most were available in the literature or derived from nationally representative survey data, including those that had the most impact on output values as determined by sensitivity analyses. Finally, while children's oral health worldwide was affected by the pandemic, this research focused solely on the impact to children in the United States.

In conclusion, this study adds to a growing body of research highlighting the impact of reduced delivery of sealants and restorative care during COVID-19 on health and health disparities (Laurencin and McClinton 2020; Mueller et al. 2021). To our knowledge, this is the first research to examine the impact of the COVID-19 pandemic on untreated dental caries and resulting loss in quality of life among children aged 7 y from low-income households. We estimated that decreased access to preventive and restorative dental services due to COVID-19 resulted in a 1.5-DALY increase per 1,000 children with the impact being almost twice as high among NHB and Hispanic children than among NHW children. Delivering sealants to 50% of eligible 1Ms by September 2022 (note that 59% of 1Ms would be eligible) could reduce these excess DALYs by about one-third and reduce disparities in excess DALYs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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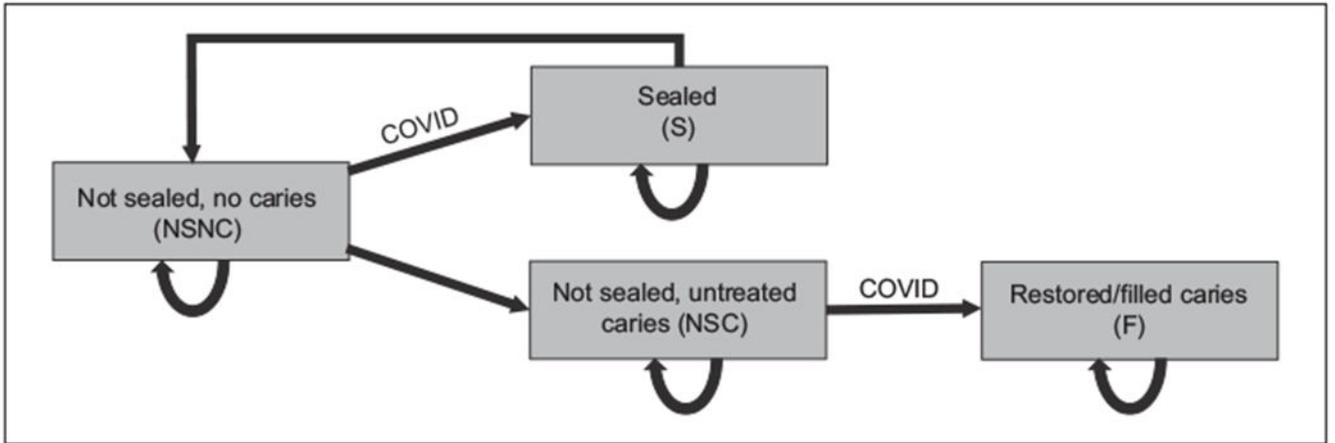


Figure 1. Tooth state transitions in simulation model. “COVID” represents transition probabilities that were affected by COVID-19.

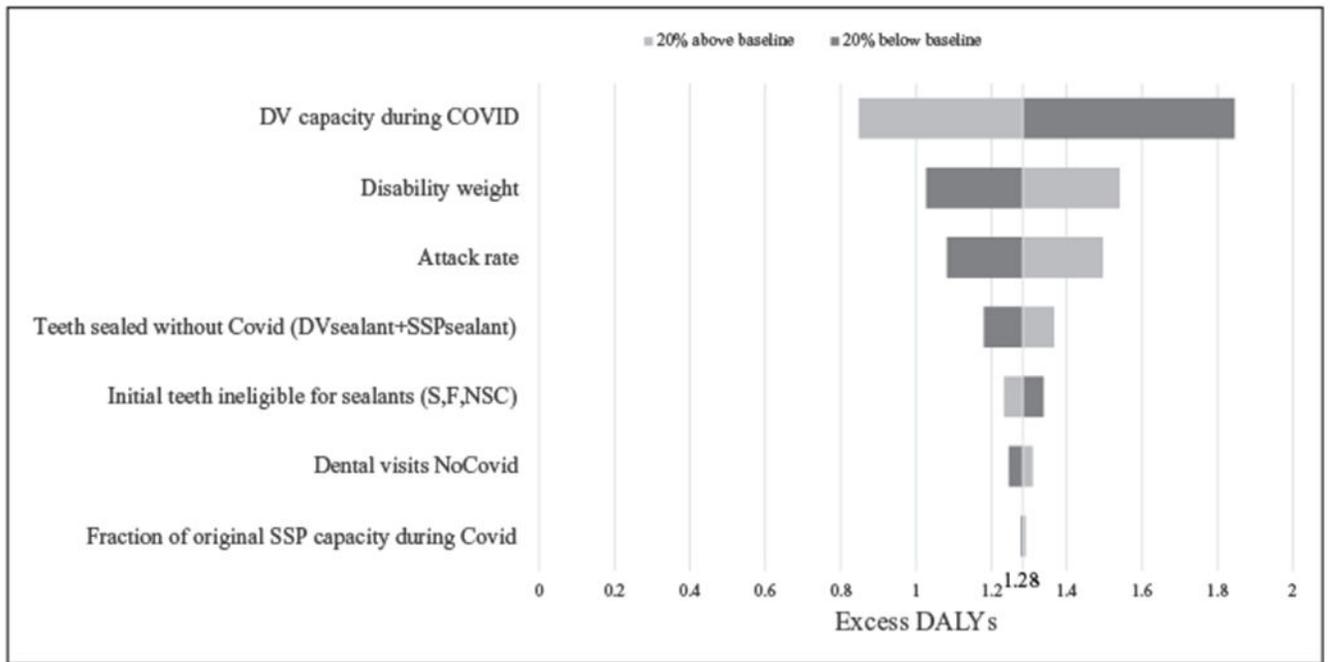


Figure 2.

Impact of parameter values on excess DALYs per 1,000 children based on sensitivity analyses when variables deviate $\pm 20\%$ from the mean values while holding all other variables constant at their mean values. DALY, disability-adjusted life years; DV, dental visit; DVsealant, probability that child with dental visit receives sealant; F, filled/restored caries; NSC, not sealed and with untreated caries; S, sealed; SSP, school sealant program; SSPsealant, probability of being sealed by school sealant program.

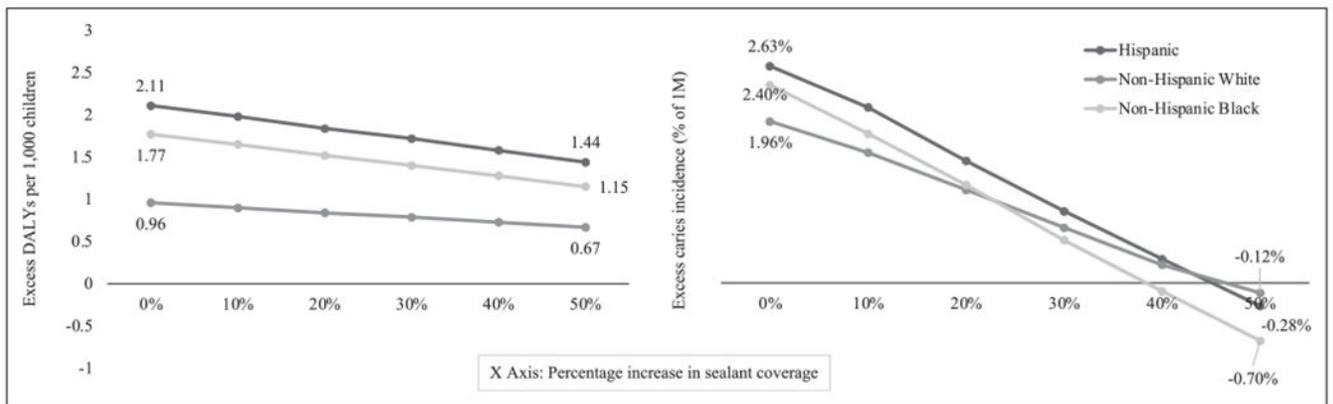


Figure 3.

Impact of increasing sealant prevalence in month 30 on DALYs and caries incidence.

Percentage of mitigation indicated in x-axis reflects the additional percentage of eligible teeth that were sealed in month 30. Difference between non-Hispanic White and other race/ethnicity groups is statistically significant, with $P < 0.001$ at the 0% mitigation level. 1M, first permanent molar; DALY, disability-adjusted life year.

Table 1.

Parameter Source, Value, and Distribution.

Parameter	Data Source	Value	Distribution for Simulation
DALY for untreated caries per person ^a	Salomon et al. (2015)	0.010/y, 0.00083/mo	Triangular on 95% CI (0.005 to 0.019)
Not sealed, no caries ^{a,b}	NHANES 2011 to 2016: all children aged 6 y; sealed by children aged 6 to 11 y of that race/ethnicity in not sealed, no caries	Model initialization: % IM in each state at baseline NHW 78.61%, NHB 84.12%, H 79.69%, all 80.20%	Adjusted by sealed value, maintaining ratio from baseline
Sealed ^d	NHANES 2011 to 2016: all children aged 6 y; sealed by children aged 6 to 11 y of that race/ethnicity in sealed	NHW 19.82%, NHB 13.71%, H 18.28%, all 17.90%	Triangular distribution on $\pm 20\%$ from baseline
Not sealed, untreated caries ^d	NHANES 2011 to 2016: all children aged 6 y; sealed by children aged 6 to 11 y of that race/ethnicity in not sealed, untreated caries	NHW 0.57%, NHB 0.57%, H 0.44%, all 0.50%	Adjusted by sealed value, maintaining ratio from baseline
Filled/restored caries ^a	NHANES 2011 to 2016: all children aged 6 y; sealed by children aged 6 to 11 y of that race/ethnicity in filled/restored caries	NHW 1.01%, NHB 1.60%, H 1.60%, all 1.40%	Adjusted by sealed value, maintaining ratio from baseline
Annual probability that sound, unsealed IM develops a cavity (attack rate) ^d	Transition probabilities NHANES 2011 to 2016: children aged 7 to 12 y; calculated with methodology from Griffin et al. (2014); converted to monthly by $1 - (1 - \text{attack rate})^{1/12}$	NHW 5.34%, NHB 7.12%, H 7.60%, all 6.57%	Triangular distribution on $\pm 20\%$ from baseline
Probability of dental visit without COVID-19	MEPS 2015 to 2018 for children aged 6 to 11 y; assumed equal probability each month	NHW 50.3%, NHB 45.3%, H 53.2%, all 50.2%	Triangular on 95% CI from MEPS
Probability sealed by SSP no COVID-19 ^c	Estimated with data from NCES (Health Policy Institute 2021), the Pew Charitable Trusts (2015), unpublished data for SSPs in 16 states funded by the CDC for SSPs, and NHANES data for children aged 6 to 11 y. See Appendix Figure 1.	Year 1 = 9.97% annually (allocated as 0% for June, July, and August and 1.11% each of the 9 remaining months). Years 2 to 4: 0%.	Triangular distribution on $\pm 20\%$ from baseline. Held constant in 0% months.
Probability that child with dental visit receives sealant ^a (aged 6 to 9 y only)	Calculated from NHANES data and other model parameters. See Appendix Table 5.	NHW 30.88%, NHB 23.72%, H 26.93%, all 27.94%	Triangular distribution on $\pm 20\%$ from baseline
Retention ^{d,c}	Formula from Quimenez et al. (2005)	Function of age of sealant. See Appendix Table 3.	None
Probability of dental visit with COVID-19 ^c	ADA data (Health Policy Institute 2021)	Regression on ADA data through February 2021; explained in Appendix Figure 2.	Triangular distribution on $\pm 20\%$ of baseline, truncated at 100% of pre-COVID-19 values as maximum
Probability sealed by SSP with COVID-19 ^c	16 CDC-funded states and national data on school closings (Parolin and Lee 2021)	No SSPs March through August 2020. Linear growth up to 25% of pre-COVID-19 rates in February 2021	Triangular distribution on $\pm 20\%$ from baseline

No. of children and first molars

Parameter	Data Source	Value	Distribution for Simulation
No. of children and first molars ^{a,d}	NCES (Health Policy Institute 2021); % in each race/ethnicity from NHANES-weighted values for children from low-income households	All 1,975,550; NHW 744,059; NHB 407,440; H 664,865	None

IM, first permanent molar; ADA, American Dental Association; CDC, Centers for Disease Control and Prevention; DALY, disability-adjusted life year; H, Hispanic; MEPS, Medical Expenditure Panel Survey; NCES, National Center for Education Statistics; NHANES, National Health and Nutrition Examination Survey; NHB, non-Hispanic Black; NHW, non-Hispanic White; SSP, school sealant program.

^aDoes not vary by COVID-19 status.

^bInformation about NHANES criteria for caries: https://www.cdc.gov/nchs/data/nhanes/2017-2018/manuals/2018_Oral_Health_Examiners_Manual.pdf.

^cDoes not vary by race/ethnicity.

^dNHANES data on race/ethnicity are collected during an interview in the respondent's home. The categories are Mexican American, other Hispanic, non-Hispanic White, non-Hispanic Black, and other race including multiracial. Our analysis did not include the other category, and Mexican American and other Hispanic were combined to create Hispanic.

Table 2.

Changes in Outcomes Attributable to COVID-19.

	Outcome (SE) ^d			
	Total	Non-Hispanic White	Hispanic	Non-Hispanic Black
DALYs per 1,000 children over 4 y ^b				
No COVID-19	4.97 (0.05)	2.99 (0.03)	6.73 (0.06)	6.57 (0.06)
COVID-19	6.45 (0.06)	3.92 (0.04)	8.80 (0.08)	8.32 (0.08)
Excess due to COVID-19 ^c	1.48 (0.07)	0.94 (0.04)	2.07 (0.10)	1.75 (0.10)
Incidence of new caries over 4 y ^d				
No COVID-19	15.48 (0.05)	12.27 (0.04)	17.51 (0.05)	18.07 (0.05)
COVID-19	17.77 (0.04)	14.23 (0.04)	20.14 (0.05)	20.47 (0.05)
Excess due to COVID-19 ^c	2.28 (0.06)	1.96 (0.05)	2.63 (0.07)	2.40 (0.07)
Sealant delivery over 4 y ^d				
No COVID-19	31.71 (0.08)	35.40 (0.09)	31.58 (0.08)	27.75 (0.06)
COVID	18.78 (0.08)	22.10 (0.09)	18.62 (0.08)	15.42 (0.06)
Deficit due to COVID-19 ^c	12.94 (0.11)	13.30 (0.12)	12.96 (0.11)	12.33 (0.09)
End of year 3 prevalence of untreated caries ^d				
No COVID-19	6.00 (0.02)	4.79 (0.02)	6.49 (0.02)	7.45 (0.02)
COVID-19	7.93 (0.03)	6.42 (0.02)	8.69 (0.03)	9.62 (0.03)
Excess due to COVID-19 ^c	1.93 (0.03)	1.63 (0.03)	2.20 (0.03)	2.17 (0.04)

IM, first permanent molar; DALY, disability-adjusted life year; SE, standard error.

^a Values are presented as % (SE) of IMs unless noted otherwise.^b Mean (SE).^c Excess significantly differs from 0, with $P < 0.001$ for all outcomes for all race/ethnicity groups. The difference between non-Hispanic White and other race/ethnicity groups is statistically significant at $P < 0.001$ in all outcomes except IM sealant delivery.^d % of IM.