Clinical Trial

School-based caries prevention and the impact on acute and chronic student absenteeism

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ABSTRACT

Background. Poor oral health is significantly associated with absenteeism, contributing to millions of lost school hours per year. The effect of school-based dental programs that address oral health care inequities on student attendance has not yet been explored.

Methods. CariedAway was a longitudinal, cluster-randomized, noninferiority trial of minimally invasive medicines for caries used in a school-based program. We extracted data on school absenteeism and chronically absent students from publicly available data sets for years before, during, and after program onset (2016-2021). Total absences and the proportion of chronically absent students were modeled using multilevel mixed-effects linear and 2-limit tobit regression, respectively.

Results. In years in which treatment was provided through a school-based caries prevention program, schools recorded approximately 944 fewer absences than in nontreatment years (95% CI, –1,739 to –149). Averaged across all study years, schools receiving either treatment had 1,500 fewer absences than comparator schools, but this was not statistically significant. In contrast, chronic absenteeism was found to significantly decrease in later years of the program (b, –.037; 95% CI, –.062 to –.011). Excluding data for years affected by COVID-19 removed significant associations.

Conclusions. Although originally designed to obviate access barriers to critical oral health care, early integration of school-based dental programs may positively affect school attendance. However, the observed effects may be due to poor reliability of attendance records resulting from the closing of school facilities in response to COVID-19, and further study is needed.

Practical Implications. School-based caries prevention may also improve educational outcomes, in addition to providing critical oral health care. This clinical trial was registered at ClinicalTrials.gov. The registration number is NCT03442309.

Key Words. Oral health; caries prevention; education; academic performance; absenteeism.

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Caries is the most prevalent noncommunicable disease in the world and disproportionately affects children from disadvantaged backgrounds, such as those from low-income or minority families.[1] Children with poor oral health face numerous barriers to academic success including missed school days, lower test performance, and difficulty paying attention; in addition, poor oral health affects functional and psychological behavior.[2,3] In 2019, a systematic review concluded that poor oral health was associated with school performance and student absenteeism.[4] In contrast, children covered by Medicaid (a government-sponsored health insurance program and primary source of dental coverage for low-income children) who receive comprehensive screening services early in life may achieve higher academic performance.[5]

Despite the potential health and cognitive benefits of early childhood oral health care, high-risk children often have lower dental service use rates.[6-8] Historical data from multiple states indicate that more than 75% of children covered under Medicaid fail to receive required dental services.[9] One in 4 children does not see a dentist at all.[9] In part to address this unmet need, multiple federal agencies, including the Centers for Disease Control and Prevention, recommend school-based dental programs, which can provide a range of effective preventive and

therapeutic services to increase access to essential oral health care[10] and reduce the burden of disease.[11,12]

Use of school-based health programs providing medical, dental, mental, and vision services may positively affect student attendance.[13,14] School dental programs can reduce the need for unplanned dental services that lead to increased absenteeism.[15] They may also improve quality of life,[16] which has similarly been shown to affect school performance.[17] CariedAway was a pragmatic cluster-randomized trial of treatments for caries provided through a school-based program.[18] Conducted in predominantly low-income minority urban students, a secondary objective of CariedAway was to assess the effect of a school-based oral health care program on educational performance.

METHODS

Design and participants

CariedAway was a longitudinal, cluster-randomized, noninferiority pragmatic trial of minimally invasive interventions for caries implemented in schools. The study was conducted in New York, New York, primary schools from 2018 through 2023, received ethics approval from the New York University School of Medicine Institutional Review Board (i17–00578). A trial protocol was previously published.[18] The primary objective of CariedAway was to assess the noninferiority of silver diamine fluoride (SDF) and fluoride varnish compared with dental sealants, the standard of care, when used in a school-based oral health care program. Clinical outcomes included caries arrest at 2 years and caries incidence at 4 years. In addition, the trial explored the effectiveness of registered nurses compared with dental hygienists in the provision and the effect of SDF, the impact on oral health–related quality of life, and the impact on school performance. CariedAway was a mobile school-based program: clinicians would visit each school sequentially, provide treatments using mobile equipment, and then move to the next school once patient care was completed.

Patient recruitment

Participant recruitment followed a 2-stage process. First, any school with at least a 50% Hispanic or Latino or Black student population and with at least 80% receiving free and reduced-cost lunches was eligible for inclusion. Second, schools were randomized to treatments and any child in enrolled schools who provided parental informed consent, child assent, and spoke English was enrolled.

Interventions

Schools were block-randomized, using a random number generator, to 1 of 2 conditions: an experimental treatment consisting of fluoride varnish (5% sodium fluoride) (PreviDent; Colgate) applied to all teeth and a 38% SDF solution (2.24 fluoride ion mg/dose) (Advantage Arrest; Elevate Oral Care) applied to any asymptomatic cavitated lesions and on all pits and fissures of premolars and molars, and an active comparator consisting of the same fluoride varnish application, glass ionomer sealants (GC Fuji IX; GC) placed on all pits and fissures of premolars and molars, and atraumatic restorations on any frank asymptomatic cavitations.

A single drop of SDF solution was dispensed into a disposable mixing well and applied with a microbrush, followed by air drying for a minimum of 60 seconds. For dental sealants, cavity conditioner was first applied to pits and fissures for 10 seconds followed by application of glass ionomer via the finger sweep technique, digitally applied until closed margins were achieved.

Treatments were provided in a private, dedicated room in each school using mobile dental equipment. Treatments in the SDF arm were provided by either dental hygienists or registered medical nurses, whereas sealants and atraumatic restorations were applied by dental hygienists. All care was provided under the supervision of a licensed pediatric dentist. Across all schools, the total average time that participants were outside of class to receive treatment was 25 minutes.

Comparator schools

For this analysis, a subset of schools that did not receive a treatment assignment was included. This group consisted of schools that were enrolled in stage 1 of the CariedAway recruitment process but did not proceed to stage 2. These schools served as nonrandomized counterfactuals, in that they met all study inclusion criteria and were found in the same geographic area, but they were not randomized and did not receive treatment.

ABBREVIATION KEY

NA: Not applicable.
SDF: Silver diamine fluoride.

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Table 1. Descriptive statistics for absenteeism and chronically absent students, by year.

YEAR	SILVER DIAMINE FLUORIDE SCHOOLS		SEALANT SCHOOLS		NO TREATMENT	
	Days Missed, Mean (SD)	Chronically Absent. % (SD)	Days Missed, Mean (SD)	Chronically Absent. % (SD)	Days Missed, Mean (SD)	Chronically Absent. % (SD)
2016-2017	7,600.53 (3,966.18)	33.99 (5.64)	7,200.33 (3,326.40)	31.81 (12.82)	8,221.85 (3,287.16)	36.92 (8.97)
2017-2018	8,360.41 (4,735.45)	36.64 (5.74)	7,373.76 (3,122.62)	33.15 (12.18)	8,275.77 (3,278.24)	40.59 (8.04)
2018-2019	7,988.44 (4,533.40)	39.01 (10.02)	7,276.10 (3,043.91)	33.86 (13.20)	7,995.85 (2,965.69)	40.28 (7.73)
2019-2020	4,718.72 (2,300.48)	34.03 (7.42)	4,352.48 (1,767.06)	31.81 (11.38)	4,606.54 (1,773.50)	35.52 (9.22)
2020-2021	7,660.28 (3,677.60)	36.71 (12.53)	7,933.95 (3,859.62)	37.61 (14.74)	8,089.39 (3,616.80)	39.1 (15.13)

Data sources and outcomes

Attendance rates for each included school were obtained for school years 2016 through 2021 from the New York City Department of Education. Student attendance is attributed to the school each student attended at the time. If a student changed schools, attendance was attributed to multiple schools. Data were extracted for total days present, total days absent, overall average school attendance, and the proportion of children classified as chronically absent. Chronic absenteeism was defined by the New York State Department of Education as any student with a total attendance of 90% or less across all school days (minimum enrollment threshold of 10 days).

Statistical analysis

Data were ordered sequentially by school and year of study. Descriptive statistics for outcomes and select independent variables were produced overall and by treatment group. Absenteeism was modeled using mixed-effects linear regression, and the proportion of chronically absent students using 2-limit mixed-effects tobit regression. Our first model (model 1) was a single-group analysis defined as $y_t = b_0 + b_1t_t + b_2x_t + b_3x_tt_t$, where t is the overall time since the start of CariedAway, x is a dummy variable indicating onset of the intervention (for example, signifying a change from a nonintervention period to an intervention period and vice versa), and x_t is their interaction. Outcome variables (y) included the total number of days absent for each school and the percentage of students who were chronically absent, and sample regression coefficients (b) represent estimated effects. Multiple treatment onsets were possible. Subsequent models introduced an additional parameter, z, representing the treatment type provided in each school (model 2), and a series of treatment-specific interaction terms including the treatment-time interaction, treatment-intervention onset, and a 3-level interaction between treatment, time, and intervention onset, defined as $y_t = b_0 + b_1t_t + b_2x_t + b_3x_tt_t + b_4z + b_5zt_t + b_6zx_t + b_7zx_tt_t$ (model 3). Models were first run in schools receiving either SDF or sealant treatment (models 1a, 2a, and 3a) and then inclusive of comparator schools, which did not receive treatment, by modifying the dummy indicator for treatment as any treatment vs no treatment (models 1b, 2b, and 3b). Schools were included as random intercepts. As a final analysis, we excluded the 2019 through 2020 school year, which was partially conducted virtually because of the effects of the COVID-19 pandemic and may have biased the results.

RESULTS

When restricted to schools that received treatment in CariedAway, our data included 193 yearly observations across 39 schools. When adding comparator schools, results reflected 52 schools and 258 yearly observations. The average student enrollment per school was 166. The yearly recorded days absent and proportion of students chronically absent are shown in Table 1.

Results for total days absent (Table 2) and chronic absenteeism (Table 3) include models for schools receiving SDF vs those receiving dental sealants (models 1a, 2a, and 3a) and then any treatment vs no-treatment schools (models 1b, 2b, and 3b). For total days absent, there was a consistent reduction in school absence in years in which treatment was provided (x indicator) as well as an increased effect when treatment was provided in later school years (xt indicator). For example, model 2b with all schools included shows a predicted reduction of 883.5 (95% CI, –1,697.0 to –69.7) missed school days in years in which treatment was provided with an additional

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Table 2. Model results for total school absences.*

VARIABLE	MODEL 1		MODEL 2		MODEL 3	
	1a†	1b‡	2a§	2b¶	3a#	3b**
***t*†† , 95% CI**	137.8 (–33.1 to 308.8)	–25.2 (–180.8 to 130.4)	138.0 (–32.9 to 308.9)	–24.8 (–180.5 to 131.0)	63.2 (–198.3 to 324.8)	–418.3[a] (–699.7 to –136.9)
***x*‡‡ , 95% CI**	–945.2[b] (–1,698.0 to 192.0)	–879.9[b] (–1,692.0 to –67.3)	–946.0[b] (–1,699.0 to –192.8)	–883.5[b] (–1,697.0 to –69.7)	–1,037.0[b] (–2,064.0 to –10.5)	–943.9[b] (–1,739.0 to –149.1)
***xt*, 95% CI**	–1,607.0[a] (–2,337.0 to –877.9)	–1,437.0[a] (–2,219.0 to –654.7)	–1,609.0[a] (–2,339.0 to –879.7)	–1,437.0[a] (–2,219.0 to 655.1)	–1,135.0[b] (–2,060.0 to –210.1)	–1,608.0[a] (–2,378.0 to –837.9)
***z*§§ , 95% CI**	NA¶¶	NA	–534.2 (–2,554.0 to 1,486.0)	154.7 (–1,802.0 to 2,111.0)	–745.2 (–2,984.0 to 1,493.0)	–1,505.0 (–3,699.0 to 689.6)
***zt*, 95% CI**	NA	NA	NA	NA	125.4 (–217.4 to 468.1)	555.6[a] (221.4 to 889.9)
***zx*, 95% CI**	NA	NA	NA	NA	4,129.0 (–1535.0 to 9,792.0)	NA
***zxt*, 95% CI**	NA	NA	NA	NA	–1,232.0 (–2,724.0 to 259.0)	NA
Constant, 95% CI	7,238[a] (6,120.0 to 8,355.0)	7,632[a] (6,676.0 to 8,587.0)	7,526[a] (5,968.0 to 9,084.0)	7,515[a] (5,759.0 to 9,271.0)	7,650[a] (5,998.0 to 9,302.0)	8,744[a] (6,844.0 to 10,645.0)
Observations, No.	193	258	193	258	193	258
Schools, No.	39	52	39	52	39	52

* Superscript letters indicate level of statistical significance ([a] $P < .01$, [b] $P < .05$). † Model 1a: Time only, no comparators. ‡ Model 1b: Time only, with comparators (silver diamine fluoride [SDF] plus sealant schools plus no treatment). § Model 2a: Multigroup, SDF vs sealant schools. ¶ Model 2b: Multigroup, with comparators (SDF plus sealant schools vs no treatment). # Model 3a: Full model, SDF vs sealant schools. ** Model 3b: Full model, with comparators (higher interactions removed). †† *t*: School year. ‡‡ *x*: Time varying (treatment year). §§ *z*: Treatment. ¶¶ NA: Not applicable.

reduction of 1,437.0 days (95% CI, –2,219.0 to –655.1) if treatment was provided in later years. Including all schools and relevant predictors (model 3b), there was an additional nonsignificant overall reduction in missed school days in schools that ever received treatment vs schools that did not (*b*, –1,505.0; 95% CI, –3,699.0 to 689.6), but this gap was significantly reduced over time (*b*, 555.6; 95% CI, 221.4 to 889.9). Indicators for the treatment-treatment time and treatment-treatment time-overall time variables were perfectly collinear as comparator schools never received treatment and were therefore removed from the final model.

For the proportion of enrolled schoolchildren who were chronically absent, single-group models (Table 3, models 1a and 1b) indicated that there was a significant yearly increase of approximately 1% in the proportion of chronically absent students each year and a significant 3% decrease for the interaction between school year and whether the school received treatment that year. Multigroup models with and without comparator schools showed a nonsignificant reduction in chronic absenteeism for SDF vs sealant schools (model 2a) and any treatment vs no treatment (model 2b). Overall model results (model 3b, inclusive of comparator schools) suggested that there was an approximate 3.5% decrease in chronic absenteeism when treatment was provided in later years. There was also a nonsignificant ($P = .054$) decrease of 7% in schools receiving treatment compared with control schools, but this effect fell by 1% over time.

Results when excluding data from the 2019 through 2020 school year removed the effect of treatment in a given year. There remained an overall reduction in days absent when comparing treated schools with untreated schools, but this effect was not statistically significant (Table 4, models 1 and 2). Similar results were found for chronically absent students, with a nonsignificant reduction in the chronically absent population in treated schools (Table 4, models 3 and 4).

DISCUSSION

In addition to school absences resulting from dental pain or infection, acute or unplanned oral health care contributes more than 30 million hours of missed school per year.[19] Although school-based dental programs were developed to treat and prevent oral diseases in children who lack access

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Table 3. Model results for the proportion of chronically absent students.*

VARIABLE	MODEL 1		MODEL 2		MODEL 3	
	1a†	1b‡	2a§	2b¶	3a#	3b**
t††, 95% CI	0.0114[a] (0.00542 to 0.0174)	0.00766[a] (0.00254 to 0.0128)	0.0114[a] (0.00543 to 0.0174)	0.00757[a] (0.00245 to 0.0127)	0.00625 (–0.00296 to 0.0155)	–0.00184 (–0.0112 to 0.00751)
x‡‡, 95% CI	0.00200 (–0.0244 to 0.0284)	0.00268 (–0.0240 to 0.0294)	0.00194 (–0.0245 to 0.0283)	0.00343 (–0.0233 to 0.0302)	0.00846 (–0.0277 to 0.0446)	0.00200 (–0.0244 to 0.0284)
***xt*, 95% CI**	–0.0369[a] (–0.0624 to –0.0113)	–0.0329[b] (–0.0586 to –0.00723)	–0.0370[a] (–0.0626 to –0.0114)	–0.0328[b] (–0.0585 to –0.00715)	–0.0328[b] (–0.0654 to –0.00026)	–0.0369[a] (–0.0624 to –0.0113)
z§§, 95% CI	NA¶¶	NA	–0.0283 (–0.0900 to 0.0334)	–0.0285 (–0.0890 to 0.0319)	–0.0498 (–0.120 to 0.0205)	–0.0681[c] (–0.137 to 0.00108)
***zt*, 95% CI**	NA	NA	NA	NA	0.00885 (–0.00322 to 0.0209)	0.0133[b] (0.00216 to 0.0244)
***zx*, 95% CI**	NA	NA	NA	NA	0.00758 (–0.192 to 0.207)	NA
***zxt*, 95% CI**	NA	NA	NA	NA	–0.00643 (–0.0589 to 0.0461)	NA
Constant, 95% CI	0.322[a] (0.287 to 0.358)	0.340[a] (0.310 to 0.370)	0.338[a] (0.289 to 0.386)	0.361[a] (0.307 to 0.416)	0.350[a] (0.298 to 0.402)	0.391[a] (0.331 to 0.451)
Observations, No.	193	258	193	258	193	258
Schools, No.	39	52	39	52	39	52

* Superscript letters indicate level of statistical significance ([a] $P < .01$, [b] $P < .05$, [c] $P < .1$). † Model 1a: Time only, no comparators. ‡ Model 1b: Time only, with comparators (silver diamine fluoride [SDF] plus sealant schools plus no treatment). § Model 2a: Multigroup, SDF vs sealant schools. ¶ Model 2b: Multigroup, with comparators (SDF plus sealant schools vs no treatment). # Model 3a: Full model, SDF vs sealant schools. ** Model 3b: Full model, with comparators (higher interactions removed). †† *t*: School year. ‡‡ *x*: Time varying (treatment year). §§ *z*: Treatment. ¶¶ NA: Not applicable.

Table 4. Model results for absences (models 1 and 2) and chronically absent students (models 3 and 4), excluding remote learning years.*

VARIABLE	MODEL 1	MODEL 2	MODEL 3	MODEL 4
t†, 95% CI	58.01 (–56.19 to 172.20)	68.75 (–48.15 to 185.70)	0.00795[a] (0.00244 to 0.0135)	0.00912[a] (0.00353 to 0.0147)
x‡, 95% CI	32.5 (–597.1 to 662.0)	127.3 (–541.6 to 796.3)	–0.00631 (–0.0365 to 0.0238)	0.00431 (–0.0275 to 0.0362)
z§, 95% CI	–550.7 (–2,703.0 to 1,601.0)	–545.0 (–2,695.0 to 1,605.0)	–0.0363 (–0.0983 to 0.0256)	–0.0357 (–0.0975 to 0.0261)
***xt*, 95% CI**	NA¶	–277.8 (–949.1 to 393.5)	NA	–0.0305[b] (–0.0625 to 0.00142)
Constant, 95% CI	7,977[a] (6,086 to 9,868)	7,946[a] (6,055 to 9,837)	0.369[a] (0.313 to 0.425)	0.366[a] (0.310 to 0.422)
Observations, No.	206	206	206	206
Schools, No.	52	52	52	52

* Superscript letters indicate level of statistical significance ([a] $P < .01$, [b] $P < .1$). † *t*: School year. ‡ *x*: Time varying (treatment year). ¶ NA: Not applicable. § *z*: Treatment.

to traditional oral health care,[20] their early integration may likewise improve educational performance. The CariedAway project provided both comprehensive dental screenings or examinations and treatment services for untreated caries, supporting preliminary analyses of early school-based dental interventions on academic outcomes. We conclude that school-based dental programs may improve school attendance and when implemented longitudinally may decrease the prevalence of children who are chronically absent. However, we are unable to discern whether effects are motivated by the impact of COVID-19 on traditional academic instruction.

Prior research suggests that the use of school-based health centers positively affects classroom attendance and seat time, reflecting the complex role of child health in education.[21,22] Our findings indicate that school-based oral health care may reduce student absenteeism, but the changes in school operations due to COVID-19 could bias results. Inclusive of all years, there was an average reduction of 940 missed school days in years that treatment was provided. There were also no

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differences in absenteeism when comparing schools receiving treatment with either SDF or dental sealants. For this latter finding, prior data from CariedAway indicated that the clinical effectiveness of SDF was noninferior to that of dental sealants when used in a school-based program, with nearly identical rates of disease prevention over time.[11] As both treatments in the CariedAway project had similar impact, nondifferential effects on secondary outcomes, such as absenteeism, may be expected.

Many schools participating in the CariedAway program received treatment during the 2019 through 2020 school year; as a result, the marginal effect of treatment may be biased due to the impact of COVID-19. Schools in New York, New York, closed educational facilities and transitioned to remote learning on March 15, 2020, and the final one-third of the school year was conducted virtually. On the one hand, attendance and achievement may decrease when transitioning to remote instruction, with low-income areas being particularly affected.[23] Indeed, publicly accessible data from 1,500 schools in New York, New York, indicated that schools with high Black and Hispanic populations were much more likely to report poor attendance during remote instruction.[24] On the other hand, the administrative confusion associated with such an unprecedented transition to remote learning may have resulted in inaccurate or unreliable reporting, and there was a noticeable drop citywide in absenteeism during this initial period.

We first attempted to explore this potential bias by including schools enrolled in CariedAway but not treated because of the onset of COVID-19. Compared with these schools, treated schools recorded a reduction of approximately 1,500 missed school days, but this effect was not statistically significant. However, this indicator reflects average attendance throughout all years of the program, inclusive of years care was not provided in treatment schools. In addition, some schools received care in multiple years, including years not affected by remote learning policies. When further restricting the data to exclude attendance records for the 2019 through 2020 school year, we found that the previously estimated reduction in absences was removed. There remained a consistent, but nonsignificant, reduction in overall absences when comparing treated with untreated schools.

CariedAway prioritized schools with predominantly low-income, minority student populations, and our findings could suggest a potential positive pathway to improved attendance via those students who are chronically absent. In contrast to accumulated absences, data reporting for the proportion of students who were chronically absent may be more robust to the effects of remote instruction, particularly as this transition occurred in the last quarter of the academic year. Although treatment onset did not have an immediate impact on this outcome (for example, reductions in the same year in which treatment was provided), there was a significant interaction for subsequent years. Overall, treated schools exhibited a nonsignificant reduction in chronic absenteeism compared with untreated ones. As before, the reduction in the chronically absent population in treated schools was not significant when removing the 2019 through 2020 school year. The 2022 New York mayor's management report documented a rise in citywide chronic absenteeism, citing continued disruptions due to COVID-19 variants and a retransition to in-person instruction.[25]

CONCLUSIONS

Despite the potential bias related to COVID-19 and the corresponding shift to remote educational instruction, our findings suggest that school-based dental programs may have a positive effect on attendance and chronic absenteeism. The clinical, socioemotional, and educational results of CariedAway underline the promise of alternative approaches to school-based oral health care, but also highlight the existing barriers and challenges to sustainable program design. For example, opacity in legislation, Medicaid policies, and state boards of dental examiners regarding financial compensation and licensing for clinical personnel directly affects the sustainability of school-based care. Alternative payment systems for school oral health care, including private practice models, federally qualified health center models, and dental support organizations may be options for a sustainable program. As well, engagement with policy stakeholders, school administrators and staff members, and the local dental community can ensure proper communication of the promise of school-based oral health care. This structural support can in turn lead to greater sustainability of oral health care services in schools. ■

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