A model for extending the reach of the traditional dental practice

The ForsythKids program

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ABSTRACT

Background. The authors describe and evaluate the short-term effectiveness of a community-based program for dental caries prevention in children.

Methods. The authors enrolled pupils in the ForsythKids program after receiving informed consent. They targeted children at six Massachusetts elementary schools, grades 1 through 3, with pupil populations at high risk of developing caries. The children underwent examination by dentists using calibrated technique and received comprehensive preventive care from dental hygienists. The authors determined effectiveness by means of comparing results of the initial examination with those of a second examination performed six months later.

Results. At baseline, 70 percent of the 1,196 participating children had decayed or filled teeth. More troublingly, 42.1 percent of the primary teeth and 31.1 percent of the permanent teeth had untreated decay. Six months after preventive intervention, the proportion of teeth with new decay was reduced 52 percent in primary teeth and 39 percent in permanent teeth. Furthermore, the percentage of children with newly decayed or restored primary and permanent teeth was reduced by 25.4 percent and 53.2 percent, respectively.

Conclusions. These results indicate that this care model relatively quickly can overcome multiple barriers to care and improve children's oral health.

Clinical Implications. If widely implemented, comprehensive caries prevention programs such as ForsythKids could accomplish national health goals and reduce the need for new care providers and clinics.

Key Words. Caries prevention; evidence-based; community-based.
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Among the most compelling points made in the surgeon general's report on oral health[1] was that caries is the most common chronic childhood disease—five times more common than asthma. Furthermore, the report indicated, 80 percent of the disease burden occurs in 25 percent of the population. In the wake of this disturbing report, and in keeping with the goals of Healthy People 2010,[2] The Forsyth Institute developed ForsythKids, an elementary school–based comprehensive caries prevention program for children. In this article, we present six-month outcome data on the ForsythKids program.

DENTAL CARIES: THE NEED FOR COMPREHENSIVE PREVENTION

Several systematic reviews make it clear that dental caries is a preventable infection.[3-10] More importantly, candidate solutions are available. For example, systematic reviews, as well as large-scale

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trials, document the efficacy of fluoride varnish and toothpaste,[11-13] dental sealants[14-18] and temporary restorations,[19-21] but not of six-month recall visits.[22]

Paradoxically, however, in spite of the aforementioned trials demonstrating efficacy of prevention, large-scale community-based effectiveness demonstration programs thus far have failed to live up to their predicted benefit.[23-27] One reason for this may be that these programs focused on the delivery of only one or two preventive measures, or on populations with a low prevalence of caries.

Thus, the critical need for a comprehensive preventive oral health care plan, particularly for children at risk of developing caries, now is even clearer, from several perspectives. Demographically, dental caries remains the single most common disease of childhood.[28] It also is a social justice issue, because the impact of caries disproportionately affects children from families of low socioeconomic status.[1] Developmentally, children with severe caries have increased school absenteeism, have trouble paying attention in school and do not keep up with their peers academically.[29,30] Biologically, caries is an infection that can be prevented and can be transmitted and, if untreated, can adversely affect systemic health.[31] Finally, from an economic perspective, the Centers for Medicare and Medicaid Services estimated that the cost of dental care will rise by 50 percent between 2004 and 2014, placing oral health care farther out of financial reach for low-income households.[32]

In planning a strategy to control a prevalent disease as a public health measure, determining the availability of evidence-based, effective preventive interventions is only part of the answer. Getting these preventive measures to those in need of care—that is, dissemination and implementation of community-based programs—is even more critical. Barriers posed by society, culture, language, fear, education, experience, demographics and avoidance must be overcome before care can be delivered effectively. The implementation strategy we present in this report circumvents many of these barriers by bringing the providers to the patient rather than bringing the patient to the providers. In this article, we describe the procedures we used, how we brought them to the children in need of treatment and how effective these treatments appeared to be under these conditions.

METHODS, SUBJECTS AND MATERIALS

Basic precepts. In developing, implementing and evaluating the ForsythKids program, The Forsyth Institute adapted the following precepts.

- Care must be of the highest quality, as described in The Institute of Medicine's report, Crossing the Quality Chasm: A New Health System for the 21st Century.[33] This report articulates six characteristics of high-quality care: safe, effective, efficient, personalized, timely and equitable.
- The program must use the best clinical evidence, based on international standards. The Centre for Evidence-based Medicine at Oxford University, England,[34] developed a matrix to define the best clinical evidence. Variations on this matrix have been used internationally by a variety of agencies, including the U.S. Centers for Disease Control and Prevention. The evidence base for the preventive interventions consisted of systematic reviews on the following topics: fluoride toothpaste,[12] fluoride varnish,[11] and glass ionomer sealants and temporary restorations.[17,21,35,36]
- Meet goals of Healthy People 2010.[2] Objective 21 of Healthy People 2010 sets out the following goals for children: reduce the proportion of children with caries from 52 to 42 percent of children; reduce the proportion of children with untreated decay from 29 to 21 percent; increase the proportion of children with molar sealants from 23 to 50 percent.
- Address the needs of U.S. children articulated in the U.S. surgeon general's report on oral health.[1] This report identifies a need to increase access to care and improve oral health generally. Specifically, the report addressed the needs of populations at high risk of experiencing dental caries, including minorities and people with low incomes.
- Comply with regulations of the Massachusetts Board of Registration in Dentistry (BORID) and national guidelines on professional standards.

ABBREVIATION KEY. BORID: Board of Registration in Dentistry. **d:** Decay in primary teeth. **D:** Decay in permanent teeth. **df:** Decayed or filled primary teeth. **DF:** Decayed or filled permanent teeth. **Dx:** Diagnosis. **HIPAA:** Health Insurance Portability and Accountability Act of 1996. **OSHA:** Occupational Safety and Health Administration. **PF:** Prevented fraction. **Rx:** Treatment.

Massachusetts BORID requires licensed dentists to perform examinations and treatment planning, and it allows licensed hygienists to perform preventive care with indirect supervision. In addition, we implemented required safety and confidentiality policies and procedures as required by the Occupational Safety and Health Administration (OSHA) and the Health Insurance Portability and Accountability Act of 1996 (HIPAA).

Institutional review and school solicitation. After the ForsythKids program was approved by the Forsyth institutional review board, program representatives, through the Massachusetts Department of Public Health, contacted all elementary school principals and nurses in Massachusetts to determine their interest in participating. To address the surgeon general's goals, we sent the solicitation only to principals and nurses in elementary schools in which more than 50 percent of the children participated in the federal free and reduced-cost meals program as defined by participation in the U.S. Department of Agriculture National School Lunch Program (to qualify for which pupils must be in families whose income is at 185 percent or less of the federal poverty guidelines). Representatives from two school systems identified two schools each as fitting this category, and we initiated the program in two schools from each location. Subsequently, we identified two additional schools in a third school system and added them after one year. In these locations, we solicited local community health centers and dentists to collaborate in accepting referrals for emergency and comprehensive care.

This community-based effectiveness program evaluated changes in a subset of children who completed examinations at the initial visit and at the six-month follow-up visit.

Two schools were in urban Boston, a community with fluoridated water in which the school population was largely African-American and Hispanic. Two schools were in urban Lynn, which also has fluoridated water and in which the school population was largely Asian and Hispanic. Two schools were in rural Hyannis, a community without fluoridated water, in which the school population was largely Brazilian-American and white. Pupils received informed-consent forms at the same time they received other school forms, normally at the beginning of the school year. We prepared the informed-consent forms at an eighth-grade reading level in languages requested by the schools, and we distributed them to children on the basis of school records of their parents' or guardians' languages. We allowed all children who returned signed informed-consent forms to participate in the program.

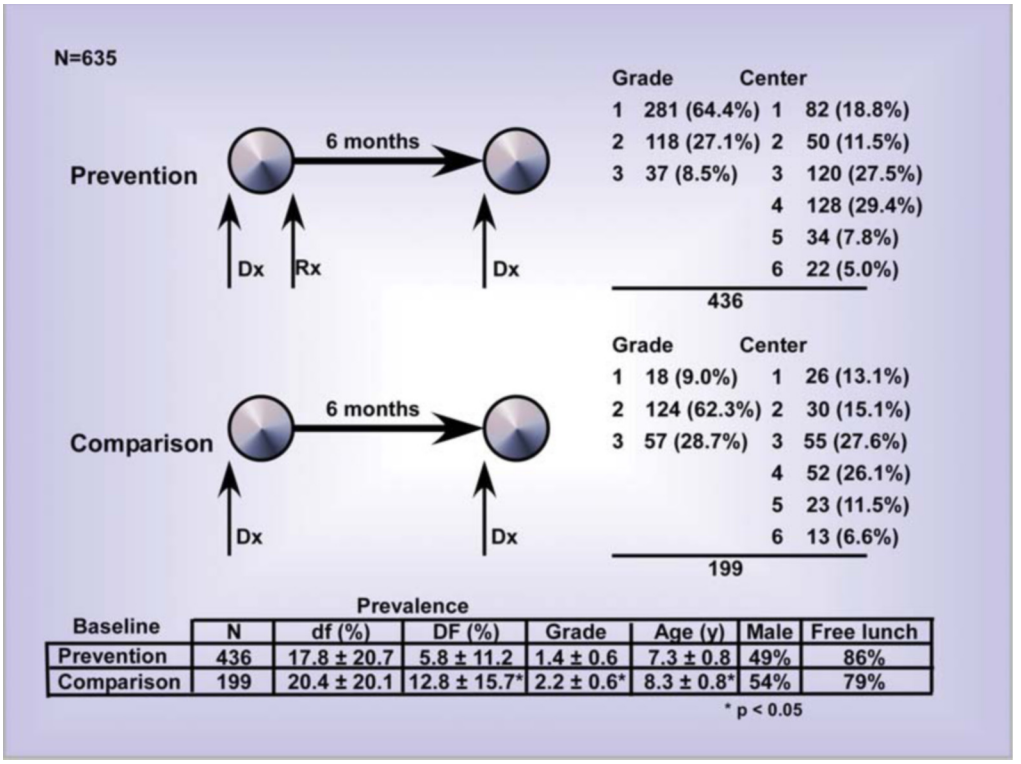
Supplies and equipment. The equipment we used included portable dental chairs, halogen lights (DNTL Works, Centennial, Colo.), standard stools (A-Dec, Newburg, Ore.), a triturator (ProMix, Dentsply, Milford, Del.), electric handpieces with couplings (Taskal Wizard NSK, Schaumburg, Ill.) and a portable sterilizer (Statim 2000, SciCan, Canonsburg, Pa.) for sterilization of handpiece couplings. Sterile disposable materials included mirrors and explorers (i-pak, Applied Health Sciences Acquisitions, Mountain View, Calif.), disposable prophalaxis brushes (Denticator, Earth City, Mo.), bibs, gloves, face masks, gowns, cotton rolls and gauze squares. Dental treatment supplies were cavity conditioner, glass ionomer sealants and temporary restoration material (Fuji IX, GC America, Alsip, Ill.), fluoride varnish (Duraphat Colgate Pharmaceuticals, Canton, Mass., or Cavity Shield, OMNII Oral Pharmaceuticals, West Palm Beach, Fla.), toothpaste (Big Red, Colgate-Palmolive Company, New York City) and toothbrushes (Henry Schein, Melville, N.Y.).

Sequencing of examinations and preventive intervention. To determine patients' oral health needs, manage expectations and ensure operational quality, dentists (R.N., M.T., J.S.) examined children who had provided informed consent in grades 1 through 3 at the six elementary schools at six-month intervals. However, only grade 1 pupils received preventive care in year one; pupils in grades 1 and 2 in year two; and, finally, pupils in grades 1 through 3 in year three. Pupils received preventive care twice per year.

The dentists underwent technique calibration ($\kappa = 0.75$), using National Institute of Dental and Craniofacial Research diagnostic criteria for dental caries,[37] and carried out all dental examinations. They dried tooth surfaces before examination but did not clean them or make radiographs. They captured examination data on electronically readable paper forms (Teleform, Cardiff Software, Vista, Calif.). The scanning software produced an image in tagged image file

format, rotated the form to be in register, performed data recognition, verified questionable characters and wrote a computer file. Data were held in a database management program (Microsoft Access, Microsoft, Redmond, Wash.) for subsequent analysis. The schools provided information on each pupil's date of birth and participation in the free and reduced-cost meals program.

Dental hygienists (E.G., V.O.) provided prophylaxis and oral hygiene instruction; provided toothbrushes and fluoride toothpaste; and placed glass ionomer sealants, glass ionomer temporary restorations (for carious teeth) and fluoride varnish, all on the basis of the dental examination and treatment plan. The dentists and hygienists prepared written reports for parents and guardians, in their native languages, regarding examination results, preventive intervention and care recommendations. Additionally, parents and guardians received referrals to collaborating local dentists or community health centers if they did not have a dentist.



Prevalence

Baseline	N	df (%)	DF (%)	Grade	Age (y)	Male	Free lunch
Prevention	436	17.8 ± 20.7	5.8 ± 11.2	1.4 ± 0.6	7.3 ± 0.8	49%	86%
Comparison	199	20.4 ± 20.1	12.8 ± 15.7*	2.2 ± 0.6*	8.3 ± 0.8*	54%	79%

* $p < 0.05$

Figure. Treatment and comparison groups of the population subsets. The authors tested two groups for differences in dental caries incidence. A treatment group of 436 children received preventive treatments and a comparison group of 199 children did not receive preventive treatment. The average baseline decay prevalence (percentage of teeth ± standard deviation [SD]), average grade (± SD) and average age (± SD) were higher in the comparison population. These groups did not significantly differ in terms of sex and free and reduced-cost meals qualification. df: Decayed and filled primary teeth. DF: Decayed and filled permanent teeth. Dx: Diagnosis. Rx: Treatment.

For emergency care, the ForsythKids team followed the school protocol. The team notified first the school nurse, then the pupil's parents. The collaborating dentists offered to set aside time to handle emergencies. Parents provided transportation. Nurses kept a log of posttreatment emergencies, had telephone numbers of ForsythKids dentists and the program director, and called the Forsyth Institute to facilitate immediate care.

Data analysis. To accommodate analysis of data from mixed dentitions, we calculated dental caries prevalence and incidence in primary and permanent teeth separately for each child. We computed prevalence by counting the number of decayed or filled primary and permanent teeth in each subject and dividing it by the number of primary or permanent teeth in that subject at that visit. To calculate incidence, we included only the teeth present at baseline and at six months. We counted the number of decayed and filled teeth at baseline and at six months and adjusted the caries increments for reversals.[38] We evaluated effects on tooth surfaces by combining selected data for each child; we restricted occlusal scores to occlusal surfaces of molars, combined mesial and distal surfaces for interproximal scores and combined buccal and lingual surfaces for smooth-surface scores.

This community-based effectiveness program evaluated changes in a subset of children who completed examinations at the initial visit and at the six-month follow-up visit. We included pupils as members of the prevention group or the comparison group depending on whether they received care at the first visit (Figure). We summarized the occurrence of new decay or restorations over six months for the two groups according to the percentage of children with

TABLE 1

Decayed or filled rate per 100 primary or permanent teeth, according to characteristics of the children and schools participating.

SCHOOL	PERMISSION (%)	SUBSIDIZED MEALS (%)	N*	TYPE	F†	BASELINE CARIES PREVALENCE ± SD (PER 100 TEETH)‡	
						Primary Teeth	Permanent Teeth
1	37.3	82.1	323	Rural	No	19.4 ± 1.7	6.4 ± 0.7
2	42.0	90.3	362	Rural	No	17.6 ± 1.8	8.3 ± 1.0
3	58.3	65.3	130	Suburb	Yes	20.4 ± 1.3	9.7 ± 0.8
4	65.5	87.7	138	Suburb	Yes	19.0 ± 1.2	9.7 ± 0.7
5	53.0	92.6	67	Urban	Yes	22.7 ± 2.1	6.4 ± 0.9
6	32.6	89.2	176	Urban	Yes	20.1 ± 2.6	5.7 ± 1.2
OVERALL	**50.1**	**86.4**	**1,196**	**N/A§**	**df/DF¶ d/D#**	**19.8 ± 0.6 9.6 ± 0.5**	**8.4 ± 0.4 5.4 ± 0.3**

* N: Number of children.
† F: Water fluoridation status.
‡ Mean ± standard error of the mean.
§ N/A: Not applicable.
¶ df/DF: Decayed and filled primary teeth/decayed and filled permanent teeth.
# d/D: Decayed primary teeth/decayed permanent teeth.

TABLE 2

Population characteristics and percentage of children with decay (at least one decayed or filled tooth).

CHARACTERISTIC	GRADE 1	GRADE 2	GRADE 3	OVERALL
Age in Years (Mean ± SEM*)	7.07 ± 0.04	8.16 ± 0.04	9.18 ± 0.05	N/A†
Number	485	395	316	**1,196**
Male (%)	51.5	57.2	51.3	**53.3**
Number of Teeth (Mean ± SEM)				N/A
Primary	14.49 ± 0.13	11.54 ± 0.14	9.15 ± 0.21	
Permanent	8.11 ± 0.16	11.54 ± 0.14	14.25 ± 0.23	
Primary molars	7.51 ± 0.04	7.08 ± 0.07	6.00 ± 0.12	
Permanent molars	3.47 ± 0.07	4.31 ± 0.05	4.30 ± 0.05	
Decayed or Filled Teeth (% of Children)				
Primary	54.0	65.8	61.7	**59.9**
Permanent	26.6	48.4	57.9	**42.1**
Teeth with Untreated Decay (% of Children)				
Primary	39.2	46.8	40.5	**42.1**
Permanent	20.2	36.2	41.5	**31.1**

* SEM: Standard error of the mean.
† N/A: Not applicable.

various numbers of newly affected teeth. The major distinction in both groups was the percentage of children with no new disease versus those with one or more newly affected teeth. On this basis, we used the presence or absence of new disease as the outcome measure for each child and logistic analysis to evaluate prevention effects relative to the comparison group, adjusting for the child's school location and grade.

RESULTS

The participating Massachusetts schools were located in rural Hyannis (centers 1 and 2), urban Lynn (centers 3 and 4), and urban Boston (schools 5 and 6). Across a three-year period, we collected data on 1,196 children who completed 2,247 visits. Of these children, 635 had repeat visits at the initial and six-month time points, and they constituted the universe of patients evaluated.

Baseline characteristics. An average of 50.1 percent (1,196) of the total number of children in grades 1 through 3 in the participating schools enrolled in this program (Table 1), and 86.4 percent of these children (1,033) participated in the free and reduced-cost meals program.

The average ages for pupils in grades 1, 2 and 3 were 7.07, 8.16 and 9.18 years, respectively (Table 2). In this population, 638 were boys (53.3 percent) and 558 were girls (46.7 percent).

As expected in this population of children with mixed dentition, the average number of primary teeth declined from grade 1 to grade 3 (14.49 in grade 1, 11.54 in grade 2 and 9.15 in grade 3), whereas the average number of permanent teeth increased (8.11 in grade 1, 11.54 in grade 2 and 14.25 in grade 3). The number of primary molars was close to a full complement of 8.00 in grade 1 (7.51) but fell to 6.00 in grade 3. The number of permanent molars (mainly the first permanent molar) was 3.47, 4.31 and 4.30 in grades 1, 2 and 3, respectively.

At baseline, 70 percent (837) of the children had decayed or filled primary (df) or permanent (DF) teeth (59.9 percent [717] having df and 42.1 percent [503] having DF) (Table 2). Of these children, 42.1 percent (503) had untreated decay (d) in primary teeth, and 31.1 percent (372) had untreated decay (D) in permanent teeth. Among children who had caries, decay or restorations occurred in 19.8 percent of the primary teeth (df) and 8.4 percent of the permanent teeth (DF). Primary-tooth decay reached a peak in children in grade 2 and declined as children lost primary teeth to either natural exfoliation or caries. Conversely, permanent-tooth decay rapidly increased from 26.6 percent in grade 1 to 48.4 percent in grade 2 and 57.9 percent in grade 3.

TABLE 3

Summary of dental caries incidence (number of newly diseased teeth per 100 teeth per year).

MEASURE	PRIMARY TEETH			PERMANENT TEETH		
	Treated	Untreated	PF (%)†	Treated	Untreated	PF (%)
All Surface Caries*	7.8	16.2	52	4.9	7.2	32
Occlusal Caries	6.8	15.9	57	4.2	7.3	42
Interproximal Caries	6.5	12.1	46	0.5	1.6	69
Smooth-Surface Caries	4.6	8.0	43	2.8	4.4	36

* Caries: Average percentage of teeth with either new decay or restorations during the six-month interval studied.
† PF (%): Prevented fraction; (Treated — Untreated) ÷ (Untreated) × 100.

The effect of a single treatment. The data set we used to analyze the effect of one round of preventive treatment included 635 children. These were children who had two examinations six months apart. There were two subsets of children: those who had an intervening preventive intervention (436 pupils) and those who missed the preventive intervention appointment (199 pupils). The primary reasons for missing the intervening preventive care were absence from school, being in second or third grade during the first year of the program or being in third grade during the second year of the program (Figure).

Descriptive evaluation of the data demonstrated that comprehensive prevention substantially reduced the incidence of caries on all primary and permanent tooth surfaces (Table 3). The largest effect was on primary teeth. In children who did not receive preventive treatment, the incidence of dental caries in primary teeth increased by 16.2 teeth per 100 teeth per year (percentage per year). In children who received treatment, the incidence of dental caries in primary teeth was significantly less: 7.8 per 100 teeth per year. The absolute caries averted in the treated group was 8.4 teeth per 100 teeth per year (16.2 – 7.8), for a prevented fraction of 52 percent ([7.8 – 16.2]/16.2 × 100]. For permanent teeth, the prevented fraction also was substantial, at 32 percent. This pattern of substantial caries reduction in primary teeth was consistent for all tooth surfaces. Specifically, the prevented fraction was consistently high for occlusal surfaces (57 percent), interproximal surfaces (46 percent) and smooth surfaces (43 percent). The pattern also was consistent for the prevented fraction of permanent teeth.

We used logistic regression to determine the effect of one round of prevention and adjust for grade level, school location and population differences. (Table 4). We defined the outcome for each child as "no new disease" versus "any new decay or restorations." Considering all surfaces, the number of children with new decay or restorations was significantly reduced from 40.6 percent to 30.3 percent in primary teeth (25.4 percent reduction) and from 30.8 percent to 14.4 percent in permanent teeth (53.2 percent reduction). Odds ratios adjusted for school location and grade level reflect the odds of exhibiting new disease for a child who did not receive treatment relative to those for a child who received treatment. We observed comparable reductions on all surfaces, which indicated that protection was provided on all tooth surfaces.

Finally, at the examination pretreatment visits, the treating dentists diagnosed multiple pupils as needing emergency care. According to the approved protocol, the dentists notified school nurses and the pupils' parents and referred the pupils for care. According to nurses' reports, only one posttreatment adverse event (an abscess) occurred in 2,247 patient visits, a rate of less than 0.05 percent.

Finally, on the basis of the number of children with new restorations, we estimated the percentage of children who saw a dentist for permanent restorations between the baseline and six-

TABLE 4

Proportion of children in whom new disease (either decay or restoration) occurred in the six-month monitoring interval.

DENTAL CARIES*	TREATED (%)	UNTREATED (%)	REDUCTION (%)	P†	OR‡ (95% CI§)
Primary Teeth					
All surfaces	30.3	40.6	25.4	.001	2.00 (1.31-3.06)
Occlusal	25.3	39.5	35.9	.0001	2.46 (1.58-3.82)
Interproximal	25.3	32.7	22.6	.003	1.96 (1.25-3.08)
Smooth-surface	18.6	24.3	23.5	.03	1.71 (1.04-2.78)
Permanent Teeth					
All surfaces	14.4	30.8	53.2	.0008	2.20 (1.38-3.48)
Occlusal	11.3	29.3	61.4	< .0001	2.78 (1.70-4.56)
Interproximal	2.5	7.7	67.5	.08	2.24 (0.92-5.48)
Smooth-surface	8.8	18.8	53.2	.004	2.27 (1.29-3.99)

* Percentage of children with at least one additional decayed or filled tooth during the six-month interval studied.
† *P* value analyzed by logistic regression analysis adjusted for grade and school.
‡ OR: Odds ratio adjusted for grade and school.
§ CI: Confidence interval.

month visits. Using this surrogate measure, we found that approximately 10 percent of the children had received care in a dental practice during this time. This modest transition to a dental practice for comprehensive treatment occurred despite the fact that after the examination and delivery of preventive care, we notified the children's parents or guardians and offered referrals.

DISCUSSION

Implementation of basic precepts. *Providing high-quality care.* In implementing the ForsythKids program, we benchmarked our care against the Institute of Medicine's[33] six quality metrics. The results indicate that ForsythKids meets all six measures:

- it was safe, with an adverse event rate of 0.05 percent;
- it was effective, leading to a 52 percent and 32 percent reduction in caries in primary and permanent teeth, respectively;
- it was efficient, as care was provided in schools, and children missed less than one hour of class time per year;
- it was personalized, in that each child was examined individually by a licensed dentist, who developed the treatment plan that was implemented by a licensed dental hygienist;
- it was timely, delivering care twice per year and thus ensuring that children were monitored and cared for in a longitudinal fashion;
- it was equitable, because it offered care to all children regardless of their ability to pay.

Use of the best clinical evidence. The best available evidence is evolving continuously. Therefore, the evidence base on which this program was developed also is changing. At the outset of the program, we found systematic reviews indicating that fluoride toothpaste and fluoride varnish are effective in preventing caries.[12,13] In addition, we noted randomized controlled trials indicating that glass ionomer sealants and temporary restorations were equal or superior to resins in preventing caries. Subsequently, we found systematic reviews of glass ionomer sealants and temporary restorations that confirmed the findings of the randomized controlled trials.[17,21,35] However, during the revision of this article, a new systematic review was published that supported the use of resin sealants and contradicted the foundational studies we had identified regarding the effectiveness of glass ionomer sealants.[36] Interestingly (and problematically), the results of previous large-scale trials of school-based sealant programs using resins demonstrated no ability to inhibit caries.[23-27] This may be accounted for by the results of the new systematic review, which measured sealant effectiveness on the basis of sealant longevity (not caries prevention). In contrast, the data we used to develop the intervention reported here rest on caries prevention as the primary outcome for sealant effectiveness.

Accordance with the goals of Healthy People 2010. Objective 21 of Healthy People 2010 sets out three goals for children that the ForsythKids

program addressed. Our data show that the program met or exceeded all three goals.

- Reduce the proportion of children with dental caries experience in their primary and permanent teeth from 52 percent to 42 percent of children (1 percent per year): ForsythKids reduced the proportion of children with caries by 2 percent per year.
- Reduce the proportion of children with untreated decay from 29 percent to 21 percent (0.8 percent reduction per year): ForsythKids reduced the proportion of children with untreated decay by 7.5 percent per year.
- Increase the proportion of children with sealants on their molars from 23 percent to 50 percent (2.7 percent per year): ForsythKids increased the proportion of children with sealants by 30 percent per year.

Address children's needs as described in the U.S. surgeon general's report on oral health.[1] This document outlines the need for increasing access to care and improving oral health, particularly in populations at high risk of developing dental caries. The ForsythKids program specifically targeted high-risk populations. This is evident in the baseline measures for children with caries (59.9 percent of children with caries in primary teeth; 42.1 percent of children with caries in permanent teeth), untreated caries (42.1 percent of children with caries in primary teeth; 31.1 percent of children with caries in permanent teeth) and sealants (3.0 percent of children had sealants at the initial visit; data not shown). For the first two measures, the occurrences were greater than the national average, whereas the occurrence for sealants was lower than the national average. Taken together, all three indicate the high-risk status of these children. As noted, we selected for the program schools in which more than 50 percent of the children participated in a free and reduced-cost meals program, as a surrogate for socioeconomic status.

The subjects, the implementation and the limitations of this program illustrate a central problem of health care disparity: that the populations in need are not isolated, but live among us.

Comply with Massachusetts BORID and national standards. The preceding four items demonstrate the ForsythKids program's ability to meet national guidelines regarding professional standards. Moreover, we complied with the Massachusetts BORID guidelines that require licensed dentists to perform examinations and treatment planning and allow licensed hygienists to perform preventive care with indirect supervision. Finally, we instituted and implemented policies and procedures to ensure that the program adhered to OSHA and HIPAA safety and confidentiality standards.

Limitations. We designed and implemented the ForsythKids program as a clinical effectiveness program[39] rather than an efficacy trial. Therefore, the design, analysis and interpretation of our study have a number of inherent limitations. In terms of design, the groups were imbalanced (see the Methods, Subjects and Materials section). We adjusted for the imbalance in the analysis by using logistic regression. For this reason, the absolute magnitude-of-effect estimates may not reflect the true changes precisely. This is indicated by the variance measures. With this reservation in mind, however, it is clear that the preventive treatments used had a clinically and statistically beneficial effect on the children's primary and permanent teeth. Furthermore, the effect is larger than that reported for other community-based oral health interventions.[23-26]

Caries diagnosis has a long history that encompasses numerous methods, varying criteria, varying content validity,[39,40] considerable professional discussion[41,42] and a new international system for evaluation.[43] In light of these overlapping systems, we elected to use a visual-tactile system (that is, dry field and an explorer) that was most familiar to practicing dentists in the United States. This approach may overestimate the occurrence of cavitated lesions (such as pits and fissures without caries) and underestimate the occurrence of early lesions (such as white spots).[44] As indicated in the preceding paragraph, even with these limitations in mind, we would expect a similar positive outcome were practicing dentists to embark on community-based elementary school prevention programs using the methods implemented here.

A critical issue in this analysis is that of the comparison group. Clearly, the groups were not randomly selected. For example, as indicated in the Methods, Subjects and Materials section and in the figure, the comparison group was older than the intervention group. However, the com-

parison group does not represent a convenience sample. Both sets of pupils came from the same population of children and the same schools, and all schools were represented in both groups. In addition, there was no bias on the part of the examiners to include or exclude any child. We treated all children who were available and willing to participate. However, one cannot say that factors we did not evaluate—such as oral hygiene, diet, intervening care and illness—may have biased the results unknowingly.

Community and population characteristics. The subjects, the implementation and the limitations of this program illustrate a central problem of health care disparity: that the populations in need are not isolated, but live among us. Consider Boston, a city of approximately 550,000 people, with approximately 110,000 children. Even with fluoridated water, three dental schools (one of which is three blocks from the two Boston elementary schools), a dental hygiene school (also three blocks from the two Boston elementary schools), 26 community health centers and more than 400 dentists in a 10-mile radius, Boston has large, easily identifiable populations of children with high levels of untreated dental caries. This need is greater than national, state or local demographics may indicate. A juxtaposition of health resources and untreated dental disease bespeaks our inability to address dental health care needs by simply training more dental health care professionals and building more clinics. To this point, authors from the Centers for Medicare and Medicaid Services predicted that attempting to solve the current health problems under the current system will almost double costs by 2014 but will not rectify the access problem.[32] Furthermore, the proposed solutions of building more clinics, training more dentists and charging higher fees are unlikely to solve the problem.[45]

An alternate solution. An alternate approach to caries is needed, one that blends the current focus on a surgical model of treatment with the far larger focus on a preventive model of care. The importance of a preventive approach is, perhaps, best understood in terms of the World Health Organization's[46] Millennium Development Goals—in particular, the oral health goals.[47] The proposed path to improvement of oral health is the provision of a basic oral health package consisting of emergency care, prevention and cost-effective interventions.[48]

Interestingly, the "system" solutions that are proposed ignore a solution that local dentists can implement readily: providing comprehensive preventive care to children in their local elementary schools twice per year. On the basis of the ForsythKids program's experience, we estimate that for an elementary school of 250 pupils, the annual investment in people and time is approximately five practice days per year for one dentist, two hygienists and two dental assistants. More importantly, the benefits and rewards for the community are enormous. Rather than depending on local, state or federal agencies, local health care professionals can deliver preventive care locally under their own control and on the basis of local standards of care.

Broader comments. To deliver widespread caries prevention that is simple, scaleable, evidence-based and cost-effective, interventions outside a dental office will be required. The ForsythKids program works toward this goal, taking low-technology, low income–producing preventive care out of the high-overhead dental office setting and introducing it into the elementary school setting. In this sense, it frees high-overhead chair time for restorative care. In one approximation of the effect on access and care, Benn[49] predicted that if comprehensive prevention was delivered outside a dental practice, it would free practice chair time for more lucrative office procedures, reduce the incidence of emergency procedures that interrupt practice flow and allow for a doubling of practice size and income. These calculations appear to be true regardless of the dentist's practice location.[49] We predict that if local health care professionals implemented comprehensive elementary school–based caries prevention programs, local practices would increase access to care and potentially reduce the need for multiple new provider programs and federal, state and local interference. We also predict that it would lead to larger practice sizes, fewer emergencies and greater income.

CONCLUSION

To increase access to care, improve oral health and reduce disparities in oral health care for children, treatments must be safe, effective, efficient, personalized, timely and equitable. Our six-month results indicate that the ForsythKids preventive program appears to be one means of achieving these goals. The ForsythKids program can be implemented locally and can reduce the incidence of dental caries in school-aged children.

Subsequent analysis of longer term results will examine additional aspects of this approach to prevention. ■

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