Longitudinal Clinical Outcomes and Cost-Effectiveness Evaluation of a Comprehensive School- Based Dental Prevention Program – ForsythKids

Longitudinal Clinical Outcomes and Cost-Effectiveness Evaluation of a Comprehensive School-Based Dental Prevention Program – ForsythKids

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Abstract

We aimed to evaluate longitudinal clinical outcomes and cost-effectiveness of a comprehensive school-based caries prevention program, ForsythKids.

In collaboration with the Massachusetts Department of Health, we solicited all principals and nurses from Massachusetts's elementary schools in which greater than 50% of students received free or reduced meals, to participate. Dentists were calibrated at baseline and hygienists trained to deliver standardized dental care. Dentists clinically examined children following guidelines provided by the National Institute of Dental and Craniofacial Research.

We assessed trends in the proportion of sound surfaces (PrSS) and teeth (PrST) remaining sound over subjects' number of visits in the program. We fit multivariable linear regression models with visit number as a predictor, adjusting for age, baseline untreated decay, gender, and previous dental care and accounting for the repeated measures by subject by using a generalized estimating equations (GEE) approach. We stratified models on the presence of untreated decay at baseline.

For cost-effectiveness analysis, an individual micro-simulation decision-analytic model was implemented to assess the cost-effectiveness of the ForsythKids program over 6 years in terms of cost per quality-adjusted life-year (QALY) and cost per sound tooth year. Analyses were conducted from a societal perspective.

On average, the proportion of sound surfaces remaining sound ranged from 95% to 99%, depending on type of dentition, baseline untreated decay, and type of surface. Further, the per-visit trend was almost flat (0.07% to 1%) in PrST and PrSS. Regarding cost analysis, the annual

cost per child in the ForsythKids program was $520. In terms of cost per QALY, over a six-year time horizon, implementing the ForsythKids program led to an ICER of $40,454 per QALY. Moreover, in terms of cost per sound tooth year, an ICER of $1,095 per sound tooth year was estimated.

In summary, while the results may be subject to attrition or selection bias, they are consistent with a protective effect of school-based comprehensive caries prevention programs. Further, the ForsythKids program appears to be a good value for money in terms of cost per QALY and cost per sound tooth year.

Specific Aims

The ForsythKids is a comprehensive school-based dental prevention program aimed at improving the oral health for at-risk children by providing preventive care. The program delivers preventive dental care and oral health education to children in underserved Massachusetts communities. For this study, the potential benefits of a comprehensive dental caries prevention program will be quantified by analyzing data from the ForsythKids program. These data include demographic data, clinical data and data about services delivered to school children aged 5 to 12 years old for a period of 6-years. The following specific aims are addressed:

1) To describe the study setting, clinical program, and baseline dental health status.

2) To estimate within-subject trends in caries experience over time, testing the hypothesis that ForsythKids decreases caries incidence.

3) To quantify the cost-effectiveness of ForsythKids from a societal perspective.

Although school-based dental prevention programs are common, there are significant differences among them. This study will evaluate the trends in clinical dental outcomes and the cost-effectiveness of a comprehensive program in relation to standard dental care using multiple source data.

The study results will address the limited research associated with the effectiveness and cost-effectiveness of comprehensive dental caries prevention programs, a gap identified by the

Community Preventive Services Task Force. It is hypothesized that such a program can be effective in delivering evidence-based and cost-effective preventive interventions in order to reduce the disparities in access to care and costs of dental care.

Overview

Some 30 years ago the National Preventive Dentistry Demonstration Program (NPDDP), studying 20,000 first, second, and fifth graders in fluoridated and non-fluoridated communities found that: "dental health lessons, brushing and flossing, fluoride tablets, mouth rinsing, and professionally applied topical fluorides were not effective in reducing dental decay – even when used all together".[1] This study caused considerable controversy given the conflict between broadly held beliefs and empirical data.[2] It also provided a case study regarding the consequences of contesting conventional wisdom.[3]

These results inform the current report from four perspectives. First, U.S. national data over the last 20 years indicates that children's caries experience and relative inequality in untreated caries continue to increase (58%, and 26%, respectively).[4-6] Second, over the same period, Medicaid spending for oral health care increased from $1billion to $15billion per year,[7] without apparent clinical benefit. Third, the Center for Health and Health Care in Schools identified at least 13 reports from U.S. federal agencies, national institutes, and organizations recommending school-based caries prevention,[8] and the Healthy People initiative sets goals for school-based caries prevention.[9, 10] Fourth, the national recommendations are based on efficacy studies, yet a comprehensive survey of 664 school-based caries prevention programs provides no clinical effectiveness statements for a comprehensive program.[11]

Given the long-standing gap between beliefs, efficacy studies, national guidance, and effectiveness data, ForsythKids embarked on a comprehensive caries prevention program that emulates, but differs significantly from, the NPDDP. In this research, we assess whether the ForsythKids program, a comprehensive school-based dental caries prevention program, has the potential to reduced children's dental burden and economic burden of dental decay. In five chapters, we report on the baseline findings, longitudinal clinical outcomes, and cost-effectiveness of this program.

Background

The Individual and Societal Burden of Dental Decay

Dental caries is largely preventable, yet it remains the most common chronic non-communicable childhood disease. Worldwide it has affected 60% to 90% of children, with the majority of dental decay untreated due to inaccessible or unaffordable dental care.[12] Similarly, when observing dental caries in the U.S., more than 50% of 5-9 year-old children have at least one decayed or filled tooth, and that percentage grows to 78% among 17 year-olds.[13-15]

At the state level, in Massachusetts in particular, in 2008, the Catalyst Institute released a report illustrating the results of a statewide survey of children's oral health. The report revealed that at least one in every four children have suffered from tooth decay by 6th grade and that almost 18% of 3rd graders in Massachusetts were attending schools with unmet dental need.[16]

Reflecting on dental decay burden, developmentally as well as socially, dental decay negatively affects the quality of life of individuals, their social participation, and economic productivity.[12, 13, 17] Developmentally, American children are missing over 51 million school hours per year due to dental problems. While socially, disparities still exist such that low-income children are 2 times more likely to be affected by dental decay and 12 times more likely to have impacted daily activities due to dental problems when compared to higher-income children – this variability endures into adolescence.[13, 14] More specifically, in Massachusetts, children from racial and ethnic minority groups experience 1.5 times more dental decay compared to their White non-

Hispanic peers. Additionally, children from low-income families experience almost 2 times more dental decay compared to their peers from higher income families.[16]

Assessment of the societal burden of dental decay is not complete without considering the direct and indirect financial impact on health systems. If a restorative approach is taken rather than a preventive one, the economic costs for oral diseases are estimated to be the fourth most expensive condition to treat around the globe.[17] More specifically, in the U.S., national dental expenditures reached almost $111 billion in 2012, accounting for 4% of overall national health expenditure.[12, 18]

In addition to direct restorative costs, indirect costs result in millions of annual lost school and work hours impeding societal progress and development. In 1996, 2.4 million days of work and 1.6 million days of school were lost in the U.S. due to oral diseases. More recently, in 2008, in Thailand, 1,900 hours of school were lost per 1,000 children due to dental problems.[12] The indirect costs of the untreated dental caries are high and extended well into adult life.

If dental decay is, in most cases, easily preventable, the question remains how the health care system is failing such that millions of American adults and children lack access to regular preventive services, and dental care is the most predominant unmet health requisite for children in the United States.[19-21]

In response to the above mentioned access problems in dental healthcare and dental burden, the Surgeon General published, for the first time, a report on oral health in 2000 directing nationwide care on the inequality and access difficulties in dentistry.[13] Since then, numerous studies and subsequent reports have acknowledged access inequalities;[19-22] and experimental and validation programs have been executed to deliver dental care to high-risk populations.[20, 23-26] Consequently, it is strongly recommended that school-based dental programs be implemented to prevent or reduce dental decay on children's teeth.[27, 28] Furthermore, school-based dental programs have been proven to increase access to care by providing dental care in schools, through a referral system or both.[29, 30]

School-Based Oral Health Programs

In 1894, the first school health program was initiated in New York and in 1904, the program expanded to include a school nurse. In 1967, the head of pediatrics at Cambridge Hospital in Cambridge MA, initiated the first school-based health center which was followed by several health centers in Dallas, Texas (1970) and St. Paul, Minnesota (1973).[31] Currently, such centers are widely implemented allover the U.S, however, only few provide both therapeutic and preventive dental care.

Types and extent of school-based dental care programs. School dental health programs are community-based programs with the focus on bringing dental prevention and care directly to the schools. These programs can deliver valued health care services by decreasing economic, language, familial, and cultural obstacles for children in the populations in which they exist.[32] Moreover, school oral health programs have the ability to diminish inequalities of access and promote the oral health of vulnerable children by taking oral health care to locations that are more suitable for this population than regular dental offices.[29] These programs are often positioned in schools near communities at high-risk for dental disease.[33]

School oral health programs are either school-based or school-linked programs. School-based dental programs are located at the schools. School-linked dental programs exist when a local community health center, such as a dental community clinic, have an official and well-coordinated linkage to the school.[34] In many smaller towns local dentists sometimes provide the school based dental exams as a volunteer service.

School-based health centers are an ideal setting to meet the unmet preventive and therapeutic oral health needs of school-aged children; however, many can only do this in a limited capacity. Most school-based health centers (84%) provide oral health education, but much fewer have the resources to provide comprehensive dental care. Currently, less than a quarter of such centers provide basic dental care to students, including dental examinations (20%), sealants (25%), and cleanings (23%). Some of these services are provided by specially trained medical providers and not dental professionals[8] (Tables 1 and 2).[35]

Further on the classification of such programs, based on the method of delivering oral care, school oral health programs can be:[34]

A. *Mobile* van programs operate through stet dental equipment that is situated on a van or other mobile vehicle and may require only an electrical outlet from the school.
B. *Portable* programs use dental equipment brought into the school, which may require special considerations for electricity, water's disposal, and space.
C. *Fixed* clinic is a full dental clinic permanently placed in a school.

Another important difference between school-based oral health programs is that the process of consent for services can vary between schools. Most programs require an active consent to be enrolled (usually with lower participation rates) while other programs adopt passive consent procedures. However, this is determined by school regulations and can differ for schools even within the same school district. [36]

In Massachusetts, school-based oral health programs offer a variety of services, ranging from screening only programs to delivering comprehensive dental care (Table 3). Due to the different needs of each community, there can be wide variation among these programs.[34]

Measuring Dental Decay in Public Health. School oral health programs are required, usually, to collect data at the end of each visit providing a quantitative list of delivered services and number of students seen at specific visits – these numbers are usually of interest for local health departments and state oral health program to follow programs' progress that they are usually funding. However, in order to evaluate the impact of a specific intervention or a program, pragmatically, we need more than just number of services delivered, actually we need to measure clinical dental outcomes.

Two of the earliest measures used to quantify caries burden were the proportion of first molars lost due to caries and percentage of decayed permanent teeth.[37] However, these measures were proven not sensitive, to less extensive levels of disease. On the other hand Bodecker's index[38] was sensitive but very complicated. Consequently, Dean and his colleagues were the first to use counts to address severity of dental decay and fluorosis. Subsequently, Klein and his colleagues (Plamer and Knutson) were the first to describe the DMF count as it is used today – number of decayed (D), missed due to caries (M), or filled (F) teeth.[37] The DMF index is an irreversible index that can be used to measure caries burden for permanent (uppercase letters) or deciduous teeth or surfaces (lowercase letters). Further, it is called DMFT to represent caries burden on the tooth level where the T stands for teeth; and called DMFS to represent the attack on the surface level as the S stands for surfaces.[37]

Additionally, the DMF index has many variations, the most commonly used ones are (1) the "def" index where the e stands for primary teeth indicated for extraction, (2) "df" index, and (3) "dmf" for primary molars only. Further, variations exist for crowned teeth, sealed teeth, or bridge pontics, depending on the intended use of the data.[37]

Although the DMF index received universal acceptance and is indeed the most commonly and widely used index to measure caries burden, it has several limitations. Perhaps the most important drawbacks are that the DMF does not account for the teeth at risk and that it gives equal weight for missing, filled, and decayed teeth or surfaces – since it is a count. It also does not account for the severity or extent (size) of the decay or filling. Further, with today's skewed caries prevalence, 20% of the population experiencing 80% of the dental decay, Significant Caries Index (SIC Index)[39] is advised to complement the DMF index to give a comprehensive summary of dental caries burden in a community.[37]

Preventive Interventions and Application Guidelines

Several systematic reviews make it clear that dental caries is a preventable infection. More importantly, preventive strategies are available. For example, systematic reviews, as well as large-scale trials, have documented the efficacy of several preventive strategies such as fluoride varnish and fluoride toothpaste, dental sealants and temporary restorations (Table 4). Furthermore, the CDC,[40] ASTDD,[41, 42] AAPHD,[43] and the Task Force[28] recommend that at a minimum, sound non-cavitated pit and fissure surfaces of posterior teeth should be sealed even if follow-up cannot be ensured. Also, when possible, a four-handed technique should be used in applying the sealant, and the sealant's retention should be evaluated annually. Additionally, these groups other than the task force recommend that fluoride mouth rinse and varnishes be used in addition to sealants for high-risk populations (Appendix A).

Therefore, given the effectiveness of dental decay prevention services in children and the huge disparities in children's oral health and access to care, school oral health programs seem to be a logical choice for meeting the needs of these children.

Preventive oral care technologies for children include a number of in-office and home care activities, of which sealants and fluorides being the most commonly used. The effectiveness of these technologies ranges from minimally (i.e. oral hygiene instruction programs[44] and screening programs[45]) to highly effective (i.e. sealant programs[46]) in reducing dental caries. Further, the evidence of their effectiveness ranges from insufficient to strongly supported. Consequently, the ForsythKids staff chose a comprehensive package of preventive dentistry services that was backed by strong evidence of their effectiveness. As an in-place care, the ForsythKids delivered sealants (in attempt to prevent pits and fissure caries[46]), Fluoride vanish (in attempt to prevent smooth surface caries[47]), and glass ionomer temporary fillings (ART) (in attempt to treat dental caries and therefore reducing the bacterial load[48, 49]). Although there is insufficient evidence to conclude that oral hygiene instructions and prophylaxis are effective in reducing dental caries progression and incidence, the ForsythKids adopted these technologies to generate a good rapport between the hygienist and the child. Finally, as a home care activity, the ForsythKids distributed fluoridated toothpastes and toothbrushes, a technology that is proven to be effective in reducing the incidence and progression of dental decay.[50]

The ForsythKids Program: Description of the School-Based Program and Baseline Oral Health Findings

Abstract

Objective: To describe the protocols and demographics for this regional school-based caries prevention program and document baseline oral health status.

Methods: In collaboration with the Massachusetts Department of Health, we solicited all principals and nurses from Massachusetts elementary schools in which greater than 50% of students received free or reduced meals, to participate. In the spring of 2004 year, ForsythKids was implemented in four schools and by 2008-2009 the ForsythKids had more than 50 schools participating in the program. Following guidelines provided by the National Institute of Dental and Craniofacial Research, participants enrolled in ForsythKids received semiannual dental examinations by a calibrated dentist, followed by preventive services provided by a standardized dental hygienist.

Results: Over a six-year period, data were collected on 6,828 children in 33 schools. The number of students per school ranged from 100-670. The overall participation rate was approximately 15%, ranging from 10% to 30%. The low participation rate resulted from the requirement that written parental permission was required to allow each student to participate. Approximately 55% of children had dental decay on any teeth at baseline; 67% had untreated decay on primary teeth, and 32% untreated decay on permanent teeth

Conclusion: Dental decay in this specific population was almost double the national average suggesting that this is at high-risk population for developing further dental decay.

Introduction

Dental caries is the most common preventable childhood disease, present in approximately 30% of U.S. school children and nearly 50% of poor, rural, and ethnic minority populations.[51] Despite an increase in the number of available dentists and hygienists providing care, the high prevalence of untreated decay in children has remained virtually unchanged since 1990. Since that time, caries experience increased from 54% to 58%, the relative inequality in untreated caries increased from 21% to 26%, and Medicaid expenditures for oral health care increased by over 600%.[6, 51, 52]

Consequently, the Center for Health and Health Care in Schools identified at least 13 reports from U.S. federal agencies, national institutes, and organizations recommending school-based caries prevention,[8] and the Healthy People initiative sets goals for school-based caries prevention.[9, 10] The national recommendations about school-based dental prevention programs are based on efficacy studies, yet a comprehensive survey of 664 school-based caries prevention programs provides no clinical effectiveness.[11]

Based on results from randomized trials, efficacious caries prevention methods are well known and recommended by the Centers for Disease Control and Prevention, the American Dental Association, and the American Academy of Pediatric Dentistry.[53] In 2000, the Surgeon General's report on oral health identified a need for school-based prevention,[13] and a number of federal agencies and organizations have recently recommended integrating caries prevention methods in schools.[53-57] More broadly, the Healthy People 2020 Oral Health Goals include school-based oral health education and caries prevention.[58] Unfortunately, these preventive interventions are often unused[59, 60] or, when implemented, are either ineffective or fail to collect critical outcome data.[1] As a result, the "real-world" clinical effectiveness of prevention methods in large pragmatic trials is unknown. Thus the persistently high prevalence of untreated decay suggests that available methods, or access to them, do not meet current needs.

The ForsythKids program began in 2004 as comprehensive school-based caries prevention program to investigate whether school-based preventive care could improve oral health. Interventions used in ForsythKids were selected from the existing caries prevention literature for which efficacy was demonstrated through systematic reviews or human randomized control trials. Preventive agents were selected from topical fluorides,[42, 47, 61-65] sealants on all teeth with carious lesions and without symptoms,[28, 41, 46, 66-68] and interim therapeutic restorations.[69-72] The hypothesis was that dissemination and implementation of comprehensive school-based caries prevention, delivered twice per year, is effective in reducing the prevalence, incidence, and severity of untreated decay while simultaneously reducing the large spending and labor requirements that characterize previous approaches to caries treatment.

In this paper, we discuss the design, dissemination, and implementation process of ForsythKids, and describe the demographic and oral health characteristics of program participants and baseline levels of unmet need.

Methods

School Selection

In collaboration with the Massachusetts Department of Health, all principals and nurses from Massachusetts Title 1 elementary schools were solicited to participate in ForsythKids. All solicited schools had greater than 50% of students receiving free or reduced meals. In the spring of 2004, four elementary schools (two in Lynn, MA and two in Hyannis, MA) indicated early interest in participation. Two elementary schools in Boston, MA would later participate. The program later expanded to enroll children in all grades at all schools instead of only K-3rd graders. By 2007, the program served children from 30 schools in the Greater Boston area. Additionally, in 2008 and 2009, the ForsythKids continued enrolling new schools reaching to more than 50 schools participating in the program (Table 5a). In addition, local community health centers and dentists interested in collaborating in providing continuing care were identified.

Institutional review and informed consent

ForsythKids was approved by the IRB of the Forsyth Institute in Cambridge, MA. Informed consent forms were created at an 8th-grade reading level and provided to students in multiple languages, per each school's request. Program staff distributed consent forms to available school nurses, who then distributed forms to schoolteachers and then to parents for signature. School nurses collected returned forms, which were then collected by program staff. As ForsythKids began in the middle of the 2003-2004 academic year, consent forms were distributed to families individually. In subsequent years of the program, consent forms were distributed to parents with all other school forms at the beginning of the academic year.

Implementation

Beginning in the spring of 2004, ForsythKids was implemented in four schools: two from an urban community with water fluoridation (Lynn, MA) and two from a rural community with non-fluoridated water (Hyannis, MA). Two schools in Boston, MA (urban community with water fluoridation) were added to the program in spring of 2005. In the first year of the program, children were examined and treated in grades K-3. In subsequent years, all children in all schools were eligible to participate. This analysis was restricted to children aged 5-12 years, as children of age outside this range were atypical.

Interventions

Participants enrolled in ForsythKids received semiannual dental examinations by a dentist, followed by services provided by a dental hygienist, including: (i) prophylaxis with a disposable rubber cup (Denticator, Earth City, Mo.) and chair-side oral hygiene instruction; (ii) distribution of toothbrushes (Henry Schein, Melville, N.Y.) and toothpastes (Big Red, Colgate- Palmolive Company, New York City); (iii) application of fluoride varnish (Duraphat Colgate Pharmaceuticals, Canton, Mass., or Cavity Shield, OMNII Oral Pharmaceuticals, West Palm Beach, Fla.); (iv) placement of sealants on all teeth with pits or fissures, with replacement if needed; and (v) placement of therapeutic sealants (also termed Atraumatic Restorative Treatment, interim therapeutic restoration, or temporary restoration) on all asymptomatic teeth with carious lesions (Fuji IX, GC America, Alsip, Ill.). Symptomatic teeth (e.g., teeth with mobility, pain, swelling, fistula, or pulpal involvement) were not treated. The preventive and therapeutic sealants used in the study were glass ionomer with the exception of 2007, when sealants were light cured resin based (Embrace, Pulpdent, Watertown, MA), and no therapeutic sealants were placed. This one-year change was made at request of the Massachusetts Department of Health.

Training, Calibration, and Standardization

To standardize examinations, dentists examined 10 students independently at baseline and discussed whether caries were present or not. Following this initial review, dentists were calibrated by examining another 10 students independently and comparing results (K= 0.75).[73] Dental hygienists delivered all services other than clinical oral exams. To standardize the delivery of care, prior to participating in the program, dental hygienists were trained to use Fuji IX glass ionomer in capsules.[74] However, no hard tissue was removed. For subsequent visits following baseline, dentists and hygienists were standardized but not calibrated.

Oral examination

Dentists clinically examined children following guidelines provided by the National Institute of Dental and Craniofacial Research.[75] The examining dentist dried tooth surfaces with gauze squares and performed clinical visual-tactile full-mouth oral examinations with the aid of halogen lights, disposable mirrors, and explorers. Full-mouth examinations included: examination of all teeth and surfaces for decay, fillings, or abscesses; inspecting presence or absence of any source of infection for all teeth including fistula, swelling, and pulp exposure; assessment of previous dental care; occlusion; and soft tissue oral pathology.

Data from clinical exams were recorded on electronically readable paper forms, which were later scanned and recorded in Microsoft Access. Examination results were prepared by participating dentists and hygienists and distributed to parents or guardians in their native languages. Recommendations for preventive intervention and treatment were also provided, and parents were given referrals to local dentists or health centers for further treatment. Any instances of the emergency care were reported to the school nurse and the child's parent.

Dental health measures

Baseline oral health measures included the proportion of children with any untreated decay on 1) any tooth or surface, of any primary tooth, and any permanent tooth. Secondary outcomes were calculated separately for primary and permanent dentition and include 1) Decayed Filled Surfaces (DFS) scores;[76] 2) the Significant Caries index (SiC) (the mean DFS of the one third pf the study population with the highest caries score);[77] 3) the proportion of children with fissure sealants (as a proxy for previous preventive care); 4) the proportion of children with treated dentition (also a proxy for previous dental care); and 5) the proportion of children with any dental infections such as fistula, swelling, or pulp involvement in any tooth, whether permanent or deciduous teeth.

Results

Over a six-year period, data were collected on 6,828 children from 33 schools (Table 5a). The number of students per school ranged from 100-670. The overall participation rate was approximately 15%, ranging from 10% to 30% (Table 5b). Approximately 48% of participants were female (51% male and 1% missing data), with a mean age at entry of 7.4 years (SD ± 1.7) (Table 6). Only 30% of participants reported race/ethnicity. Among these, close to half reported being Black, Asian, or more than one race.

Approximately 55% of children experienced dental caries on one or more teeth at baseline; 34% had untreated decay on any tooth, 29% had untreated decay on primary teeth, and 9% had untreated decay on permanent teeth (Table 7). For primary teeth, mean dfs and SiC were 2.7 and 7.5 surfaces, respectively. For permanent teeth, the mean DFS was 0.5 surfaces and SiC was 1.5 surfaces. Across participating schools, the mean dfs ranged from 0.5 to 4.3 surfaces, and SiC from 1.5 to 11. Across the schools, mean DFS ranged from 0.03 to 1.2 surfaces, and SiC ranged from 0.08 to 3.5 surfaces (Table 8).

The proportion of children with any clinical history of previous dental care (e.g., sealant or filling recorded) ranged from 38 to 81% across schools. The proportion of children with at least one sealed permanent tooth was 26%. The proportion of children with dental infections ranged from 1 to 13%.

Discussion

The schools participating in the ForsythKids program are located in urban, suburban, and rural areas, some with and some without community water fluoridation. Across all schools, students are primarily from economically disadvantaged households – based on proportion of children receiving reduced or free lunch meals.[78] Nearly one-third of participating children had untreated caries at baseline, and approximately a quarter of children had prior preventive sealants despite more than half of the children having received prior dental care. The proportion of children aged 5-12 years with untreated decay was twice the national average.

Almost all the schools participating in ForsythKids are located within one to eight blocks of either a federally qualified community health center or dental school, each of which accept Medicaid. Thus, it is possible that increasing geographic access to affordable health care does not reduce disparities in oral health among economically disadvantaged children.

Other possible barriers to effective oral health care include time, perceived and actual costs, fear, knowledge, and cultural and social norms. A national survey of adults indicated that many who forego dental care do so because of lack of time, anxiety about dental visits, beliefs that dental care is not needed, or costs—even among adults with private or Medicaid insurance.[79] It is likely that parents' time constraints and beliefs about dental care also present barriers for schoolchildren to access basic oral health care, as do language barriers and income restrictions.[80]

School-based prevention can circumvent these barriers by bringing effective care directly to children, reducing inequalities stemming from socioeconomic barriers or cultural norms. Both the Centers for Disease Control and Prevention and the American Dental Association support school-based prevention.[66] However, school-based prevention can be effective only if parents enroll their children and children participate in the program. Low participation may be the largest challenge facing school-based prevention programs.[81]

In the ForsythKids program, distributing consent forms along with other school documents at the beginning of the academic year likely increased informed consent rates. However, traditional active consent, through which parents must sign a form to “opt in” to programs, results in multiple opportunities for omission, such as misplaced forms, even among parents interested in the program.[82] Alternative approaches to consent, such as passive consent — in which all children are included unless parents refuse care (i.e., “opt out”) — may be more effective in increasing participation rates. Additional analysis is needed to determine whether nonparticipants have equal, greater, or lower need for school-based oral health prevention than participants, and is forthcoming in subsequent chapter.

Data from ForsythKids will be used to estimate the association between the number of treatments children receive and the trends in the proportion of sound surfaces remaining sound over subjects' number of visits (PrSS). Additional analyses include comparative effectiveness and cost-effectiveness analyses to address whether the clinical benefits of ForsythKids justify additional costs when compared to standard dental care. School-based care presents an opportunity to reach a large number of underserved children without disrupting learning, potentially reducing disparities in oral health and attaining Oral Health 2020 goals.

Longitudinal Clinical Outcome of School-Based Comprehensive Caries Prevention Program – ForsythKids.

Abstract

Objective: We aimed to evaluate longitudinal clinical outcomes of a comprehensive school-based caries prevention program, ForsythKids.

Methods: In collaboration with the Massachusetts Department of Health, we solicited all principals and nurses from Massachusetts elementary schools in which greater than 50% of students received free or reduced meals, to participate. Dentists were calibrated at baseline and hygienists trained to deliver standardized dental care. Dentists clinically examined children following guidelines provided by the National Institute of Dental and Craniofacial Research. We assessed trends in the proportion of sound surfaces remaining sound over subjects' number of visits (PrSS) in the program. We fit multivariable linear regression models with visit number as a predictor, adjusting for age, baseline untreated dental decay, gender, and previous dental care and accounting for the repeated measures by subject by using a generalized estimating equations (GEE) approach. We stratified models on the presence of untreated decay at baseline.

Results: On average, the proportion of sound surfaces remaining sound ranged from 95% to 99%, depending on type of dentition, baseline decay, and type of surface. Further, the per-visit trend was almost flat (0.07% to 1%) in PrSS. The results depended on baseline untreated dental decay with most of the beneficial trends occurring in children with baseline untreated dental decay, those who needed prevention.

Conclusion: The results may be subject to attrition or selection bias but are consistent with a protective effect of school-based comprehensive caries prevention programs.

Introduction

The burden of children's dental decay seems to have shifted to low socio-economic-status (SES) groups with currently about a quarter of the population experiencing 80% of the dental decay and therefore increasing the inequality in access to care.[83] Consequently, there is a need for effective preventive measures, such as comprehensive school-based dental decay prevention programs, targeting the high-risk population to reduce this societal burden.

For medical health, there are many School-Based Health Centers (SBHC) to address physical and mental issues. Consequently, such centers are successfully providing primary health care and preventive health care services; and improving access among underserved populations during the school day, allowing children to stay in the schools and improving their educational gain.[84] However, most of these centers do not have an oral health component or have only screening services.[34]

School-based dental programs (SBDP) are an effective way to improve access, reduce dental decay, and prevent further decay as has been the case for many general health interventions (i.e. obesity and asthma).[85] In fact SBDPs are recommended by several agencies, institutions, and associations such as WHO, CDC, ADA, ASTDD, AAPHD.[17, 41, 43, 86] Consequently, many states fund such dental health programs.[34, 36]

Yet SBDPs vary widely in scope of services provided.[87, 88] Most school-based health centers (84%) provide oral health education, but much fewer have the resources to provide comprehensive primary dental care. Currently, less than a quarter of school heath centers provide basic dental care to students, including dental examinations (20%), sealants (25%), and cleanings (23%). Some of these services are provided by specially trained medical providers and not dental professionals.[89]

The aforementioned interventions (i.e. sealant and fluoride varnish), evaluated in controlled trials, did actually show a preventive effect on dental decay.[46, 47, 50, 64, 65, 90] Nonetheless, whether the treatment effect observed in well-controlled clinical trials would also be realized in the pragmatic day-to-day operation of such programs; and whether the combination of such interventions would be effective in preventing dental decay – are unknown.[91]

Although there have been some attempts to evaluate comprehensive programs such as the National Preventive Dentistry Prevention Program (NPDPP)[1] and Children's Dental Health Initiatives Program (CDHIP) in California,[92] both studies leave important questions unanswered; the NPDPP implemented a sub-optimal study design (i.e. enrolled high-class schools and majority of enrolled children were not high risk children). Additionally, the CDHIP had a short duration of follow-up, likely too short to demonstrate a realistic preventive effect.

In contrast, the ForsythKids is a comprehensive school-based caries prevention program operating in schools serving primarily low-income families in Massachusetts. ForsythKids providers used all of the available caries preventive agents for which there is evidence of efficacy, on all teeth and surfaces, and offered students care at least twice yearly in every grade at participating schools. The effectiveness of such a comprehensive strategy is unknown. In this paper we report the 6-year longitudinal clinical outcomes following children’s initiation of care throughout program’s period.

Methods

ForsythKids was a 6-year longitudinal open cohort study, approved by the Institutional Review Board at the Forsyth Institute. The study was 'pragmatic' in that there were very few enrollment restrictions; rather, for the most part the program was executed, as it would be outside the context of a study.

Children in this cohort received dental care through ForsythKids, an institution-run school-based comprehensive prevention program. The program began in 2004 in four schools and was enrolling children in K, first, second, and third grades. In the following year, two more schools joined the program. The program later expanded to enroll children in all grades at all schools. By 2007, the program served children from 30 schools in the Greater Boston area. Additionally, in 2008 and 2009, the ForsythKids continued enrolling new schools reaching to more than 50 schools participating in the program.

Dental examination, intervention, and data collection

Dental examinations were provided on site at the schools using portable dental equipment. Dentists examined children who had provided consent forms. The examining dentists were calibrated using National Institute of Dental and Craniofacial Research diagnostic criteria for dental caries ($\kappa = 0.75$),[25] and they carried out all dental examinations. No radiographs were taken, only visual examination after teeth were dried. For more details about the study population, enrollment, program's services and implementation see the previous chapter.

Based on the dental examination and treatment plan, dental hygienists provided prophylaxis and oral hygiene instructions; distributed toothbrushes and fluoridated toothpastes. They also provided fluoride varnish, glass ionomer sealants and glass ionomer temporary fillings. Parents were informed, in their native language, about dental examination findings, recommended preventive interventions, and required dental treatment. If the parents did not have a family dentist, they received dental care referrals to collaborating local dentists and community health centers and an advocate followed up with them.

All examination data were captured and stored electronically for subsequent analyses. For demographic data, schools provided information on student's date of birth while parents provided information on gender, race, and ethnicity on the consent form.

Data cleaning, outcome measures, and variables included in the analyses.

Records were excluded for schools with less than 80 students participating in the program over the program period; that had less than an overall four Forsythkids visits; or had less than two visits annually. We retained visits for any student seen at an eligible school at any point in their history, even if those visits occurred at an otherwise excluded school.

Enrolled children were followed longitudinally for the duration of the program, and their data were linked longitudinally using full name and date of birth. They received up to two annual visits on site at schools, which we numbered for each child successively regardless of time elapsed between the two visits. Records were excluded for children with age at entry less than 5 or greater than 12; for children who could not be reliably linked to their baseline visit; and for visits greater than 7 due to scarcity of data. The resulting analytic sample comprised 33 schools from which we had 6,936 children who completed 18,393 visits over a 6 year time period.

For each child examined and treated, data were recorded at the tooth and surface level. Baseline oral health measures included any previous filling, any previous sealant, and any untreated decay. All baseline oral health measures were recorded at each visit in addition to placement of sealants or temporary fillings (in separate fields), at the tooth and surface level.

Primary outcome measures in this evaluation were: (1) the proportion of sound surfaces remaining sound over visits (PrSS); (2) the proportion of sound teeth remaining sound over visits (PrST); and (3) Average Decayed or Filled Surfaces (DFS) scores along with proportion of decayed or filled surfaces. We created these outcome measures for all teeth and separately for permanent and deciduous teeth. Sound surfaces were defined as not being filled, decayed, or missed. The proportion outcome was defined as number of surfaces that are sound at visit *n* divided by number of sound surfaces at risk at visit *n-1*.

In this analytic set, there were some records where the surface or the tooth was coded as decayed or filled at visit *n-1* and sound at visit n. In these instances, we carried forward the last diagnosis and considered the tooth or surface to be filled due to the difficulty of distinguishing between the tooth colored fillings and the tooth structure. Further, there were some instances were the same tooth was coded as permanent and deciduous. In this circumstance, we coded the tooth as permanent assuming that the child had so called ‘shark teeth’ and that the primary tooth had been exfoliated.

At a child’s initial visit, we derived an indicator of previous dental care according to whether any previous treatment was noted anywhere in the mouth, including sealant or previous temporary or permanent restoration including crowns. We also derived indicators regarding each subject’s oral health status at their initial (baseline) visit: any untreated decay; any decay (treated or untreated); and number of teeth with untreated decay.

Statistical analysis.

We used generalized estimating equations with the identity link and an exchangeable correlation matrix to evaluate the rate of change in the proportion of sound surfaces remaining sound over visits in relation to number of visits at the Forsythkids program, up to 6 post baseline visits. For primary analyses, we adjusted for age at examination (exact, in years, based on date of birth and exam date; where dates were missing the day it was assumed to be the 15th), gender, baseline untreated dental decay, and previous dental care (yes/no).

Children's race is a potential confounder yet was missing for a large proportion. Thus, instead of including it as a regression covariate in primary analyses, we performed sensitivity analyses to evaluate the effect of race on regression results when adjusting for race when known; restricting our analyses to children whom race was unknown; and restricting our analyses to children reported race without adjusting for it.

Some schools were in communities with fluoridated water, while others were not. Therefore, we performed sensitivity analyses when adjusting for individual school via indicator variables to ensure that water fluoridation was not a source of confounding; and when adjusting for water fluoridation via indicator variable (yes/no) to assess the fluoridation effect on the per-visit rate of change in the proportion of sound surfaces remaining sound over visits.

For DFS and DFS proportions, we calculated simple averages over visits. All statistical analyses were carried out in STATA 14.1.

Results

Of the 52 schools visited by the Forsythkids, 33 were included in final analyses that comprised 6,828 children who completed 18,393 visits. Of these children, nearly 25% had only one visit with no follow-up visits and approximately 38% had only one follow-up visit. The mean gap time between visits was 208 (SD +/- 98) days.

The mean age at entry was 7.4 (SD +/- 1.7) years; nearly 57% of the children were aged 7 or younger at their first visit, and approximately half the children were girls. Among the 30% reporting race, approximately half reported being either Black, Asian, or more than one race (Table 6).

The mean DFS scores were slightly increasing over visit, ranging from 0.5 to 1.2, with an average increment of 0.13 per visit. Further, the mean dfs scores were increasing up to the fifth visit reaching 4.2, however, it started to decline reaching 3.4 at the 8th visit. Yet, the dfs proportion for deciduous teeth continued to increase slightly (Table 9).

The proportion of overall, adult and deciduous, sound surfaces remaining sound ranged from 98.6% at second visit to 99.2% at seventh visit. Further, when stratifying by type of dentition, this proportion was similar to the proportion for the teeth overall. Also when limiting to smooth surfaces remaining sound, for both types of dentition and overall, again similar proportions were estimated. However, for occlusal surfaces of permanent first molars, this proportion was slightly lower (Table 10).

In multivariable models, the average rate of change in these proportions was increasing in relation to number of Forsythkids visits. The estimated per visit increase was approximately 0.1% [95% Confidence Interval (CI) 0.07%, 0.2%; $P<0.0001$] per-visit in any surface, a trend that was similar to the trend for permanent and deciduous teeth, and to some degree smaller for occlusal surfaces of permanent first molars (Table 11).

The per-visit increase in this proportion depended on presence of dental decay at baseline. The children with baseline decay showed a higher (better) trend with number of visits, while children with no baseline decay showed little or no trend with visit number (Table 11).

Restricting analyses to subjects who reported race, did not report race, or including both, did not meaningfully affect the magnitude of any of the trend estimates. Further, when stratifying by water fluoridation, again these results did not meaningfully change.

Discussion

In a sample of 33 Title 1 schools in the Boston area, on average, the PrST and PrSS ranged from 96% to 99% for the children who participated in the ForsythKids school-based program with a per-visit trend that was almost flat (0.07% to 1%) in PrST and PrSS. To our knowledge, the most impressive caries-reduction that has reportedly been reported is 80%, which is achievable via sealant application.[46] However, this reduction is limited to permanent molars only. On the other hand, the ForsythKids program delivers comprehensive full-mouth preventive services leading to reducing the probability of decay on all teeth, not only first permanent molars, resulting in such high PrST and PrSS.

The children in the ForsythKids program could have received therapeutic or preventive dental care outside the program via a family dentist or other dental specialist. However, several results imply that if such outside dental care occurred it did not have significantly affected our results. Particularly, 1) the high baseline dental decay prevalence despite the fact that schools were within one to eight blocks from either a federally qualified health center or a dental school indicates that children in this specific population did not optimally utilize such care; and 2) there was a high degree of consistency in the trend of PrSS and PrST across schools.

Baseline findings indicated that untreated decay was present in more than a quarter of the children, which may be considered at higher risk of developing dental decay compared to their decay-free counterparts. Further, in our longitudinal analyses we found the trends were more beneficial in children with baseline untreated decay. Therefore, the ForsythKids helped the children who had the most unmet needs and it might be assumed that targeting such program to at high-risk children can only be more beneficial and cost-effective.

If our estimates reflect the true preventive effect of the program, it would mean that offering the Forsythkids program at the national level to children as soon as possible may lead to a significant reduction in dental caries experience, not only dental decay. Using simple math, we expect that such a program may lead to a reduction in the dft, dfs, DFT, and DFS by >50%, 45%, 40%, 40%, respectively.

Despite the fact that only 1% and less than 1% of smooth surfaces at deciduous and permanent level, respectively, developed decay over the program period, newer materials might allow even further reductions. Specifically, silver fluorides have greater preventive effect compared with regular fluoride varnish as was used in ForsythKids.[93]

Some 30 years ago the National Preventive Dentistry Demonstration Program (NPDDP), studying 20,000 first, second, and fifth graders in fluoridated and non-fluoridated communities concluded that oral hygiene instructions, brushing and flossing, fluoride treatments are not effective in reducing dental decay – even when used all together.[1] This study caused considerable controversy given the conflict between broadly held beliefs and empirical data[2].

However, ForsythKids differs significantly from the NPDDP in several ways. First, we used different interventions, specifically fluoride varnish instead of gels, and glass ionomer sealants for both prevention and treatment instead of only for prevention. Second, and perhaps most salient, the study population differs in being from schools with 50% of children participating in free or reduced lunch meals program and with the majority of children from racial minority groups.[78] In contrast, schools that participated in the NPDDP were mainly of middle or higher economic class and with the majority of enrolled children being White. It stands to reason that the preventive and/or treatment effect would be greater in children at higher risk, such as those included in ForsythKids versus the NPDDP. Part of ForsythKids is referral for follow-up care with community dentists; because only a low proportion of ForsythKids subjects received such follow-up care,[25] we assume that many of the participants are simply not receiving the standard of dental care for the U.S., through which many children are at low-risk of dental decay specifically because their families bring them to dentists on an annual or semi-annual basis.

A primary limitation of this study is the lack of a control group. Instead we tracked longitudinal trends in students' PrST and PrSS throughout their participation period. Consequently, the study population was subjected to attrition either due to administrative censoring or due to the fact that students simply leave the program. This brings up the possibility for selection bias, i.e. perhaps the children with the longest duration of care differ from those with shorter follow-up. To address this issue, we performed several sub-group analyses restricting to children with similar total number of visits (3, 4, or 5). The results did not materially change, and the temporal trends remained almost flat as in the primary analyses.

Another limitation is that only 30% of children reported race. Yet, it is well established that children from racial minorities experience higher dental decay. In an effort to address this concern, we conducted several sub-analyses to probe the robustness of the results to potential sources of bias. In separate regressions, we re-fit the GEE regression model restricted to subjects who (1) reported race; (2) did not report race; and (3) regardless of whether race was reported or not. However, the results did not vary in any way that altered the interpretation. This could be due to the fact that the majority of the children in participating schools were from racial minority groups, according to data from National Center for Education Statistics.[78]

In summary, this study, though with limitations, provides valid results that support the use of comprehensive school-based oral health prevention programs. Given the focus on Title I schools, it would be unwise to generalize findings from this study to the whole U.S. schoolchildren, and the lack of an untreated control group precludes formal estimation of effectiveness. Nevertheless, the study provides reliable evidence of effectiveness that was robust to a range of sensitivity and bias analyses. In follow-up work, we are performing cost effectiveness analysis that will inform decisions to implement similar programs in other communities of high-risk children.

Cost-Effectiveness of a School-Based Comprehensive Caries Prevention Program for Children – the ForsythKids

Abstract

Objective: To estimate the cost-effectiveness of the ForsythKids program based on ForsythKids data and NHANES data.

Methods: An individual-level simulation Markov model was developed to compare the cost and outcomes of the ForsythKids program over a 6-year time horizon versus standard dental care. For the base-case, eight Markov submodels were developed representing 1st and 2nd permanent molars, each consisting of three health states simulating teeth being sound, decayed, or filled. Input data for the ForsythKids arm were based on ForsythKids data whereas input data for standard dental care arm were based on multiple sources including NHANES data. The economic evaluation was performed from a societal perspective. The incremental cost per quality adjusted life year (QALY) and per sound tooth year were calculated.

Results: The incremental cost effectiveness ratios (ICER) were estimated to be \$40,454 per QALY and \$1,095 per sound tooth year. In probabilistic sensitivity analysis, at a willingness to pay (WTP) threshold of \$50,000, 75% of the simulations were cost-effective and below \$50,000.

Conclusion: The ForsythKids was cost-effective at a societal (WTP) threshold of \$50,000 per QALY while showing a trend in reduced ICER over time. Further, the ForsythKids cost savings depended on number of enrolled children.

Introduction

Despite the fact that Medicaid healthcare expenditures for oral care increased by over 600% from 1990 to 2010, dental decay continues to be a major problem.[6, 51, 52] The burden of dental decay seems to have shifted predominantly to the low socio-economic-status (SES) group with currently about a quarter of the population experiencing 80% of the dental decay.[83] Consequently, there is a need for effective preventive measures. Accordingly, a comprehensive school-based dental decay prevention program targeting these high-risk children has been evaluated for cost effectiveness in this paper.

School-based dental decay prevention programs are recommended by national as well as international agencies as an effective way to reduce disparities.[28, 41-43, 86] More specifically, school-based sealant programs are demonstrated to be effective and cost-effective in reducing dental decay in permanent molars.[46, 94, 95] Weintraub and colleagues have evaluated the cost-effectiveness of universal delivery of sealants compared to no delivery among children of low SES and observed that universal delivery is cost effective with an incremental cost-effectiveness ratio (ICER) of $81.96 per additional restoration-free tooth-year over a time horizon of 11 years.[96] Further, Griffin and colleagues have assessed the cost-effectiveness of targeting sealant placement at the 1st permanent molars level compared with universal delivery. They reported that targeted sealant placement dominated (i.e., lower cost and higher benefits) universal sealant delivery. Additionally, they stated that it would cost $23.42 to go from not sealing any teeth to sealing all teeth and $73.96 to go from targeted sealant to sealing all teeth.[67]

On the other hand, comprehensive school-based dental decay prevention programs consisting of a combination of preventive measures including sealants, topical fluoride treatments, and oral health promotion or instructions are debated whether they are cost-effective or not. Bohannan and colleagues found that, in a comprehensive school-based dental prevention program, the only effective intervention is actually sealants. Although clinically effective, it was concluded by these investigations that it is not cost effective.[1] On the Other hand, Weintraub et al. presented a different conclusion that supported sealants as cost-effective.

Currently, the community preventive task force (an independent, nonfederal, unpaid panel of public health and prevention services, programs, and policies to improve health; and its members are appointed by the director of the CDC) indicates that there is insufficient evidence to determine whether comprehensive dental decay prevention programs are effective or cost-effective in reducing dental decay among children at high-risk.[28] Therefore, we aimed to evaluate the cost-effectiveness of the ForsythKids program, an institution-managed comprehensive school-based dental decay prevention program among children 6-12 year-old from a low SES background in Massachusetts, compared with standard dental care over a 6-year time horizon.

Methods

Study population and the Forsythkids program

Over a six-year period, data were collected on 6,828 children from more than 50 schools in Massachusetts. Schools were solicited to participate in the program if they had greater than 50% of students receiving free or reduced meals indicating that the majority of children were from low SES backgrounds. The number of students per school ranged from 100 to 670. Approximately 48% of participants were female, with a mean age at entry of 7.4 years (SD ± 1.7).

The ForsythKids program is a comprehensive school-based caries prevention program operating in schools serving primarily low-income families in Massachusetts. ForsythKids providers use a comprehensive combination of the available caries preventive agents and methods for which there is evidence of efficacy, on all teeth and surfaces, and offer students care at least twice yearly in every grade at participating schools.

In each ForsythKids visit the following services were delivered: (1) oral hygiene instructions; (2) prophylaxis; (3) toothbrushes and toothpastes; (4) application of fluoride varnish; (5) placement of sealants, with replacement if needed; and (6) placement of therapeutic sealants (also called ART) on any asymptomatic carious tooth. For more details about study population, enrollment, program's services and implementation see the second chapter in this thesis.

Standard dental care

Data on standard dental care were obtained from multiple sources (Table 12). Tooth- and age-specific dental decay probabilities were obtained from the National Health and Nutrition Examination Survey 2003-2004 (NHANES 03-04).[97] From these data, we selected 6-12 year-old children from families with poverty-to-income ratio of ≤1.85 (poverty indicator). In NHANES, data on oral health and household income were obtained from dental examination and home interviews, respectively. Dental examinations were conducted in the NHANES Mobile Examination Centers (MEC) by trained and calibrated dentists following Radike criteria.[98]

Model overview.

We developed a Markov micro-simulation model that integrated clinical and economic data from the ForsythKids program and other sources to estimate the cost-effectiveness of the program compared with standard care over a 6-year time horizon. Dental decay initiation, progression, and treatment are based on 8 independent Markov submodels, representing the permanent molars. The model has the following health states: sound (i.e., no disease), dental decay (not including incipient decay, only cavitated), filling (i.e., any type of restoration), and a health state leading to an emergency room visit (Figure 1). A child could experience further decay after the tooth was already filled. Notably, we did not account for missing dentition because it is highly unusual for children at this age to have their teeth extracted. The cycle length of the model is one year.

The model was established on three parameters: (1) transition probabilities, which dictate the switch between the different health states for each cycle, (2) costs of the prevention programs i.e., the ForsythKids program and the costs of standard dental care, and (3) health state utilities, which indicate how the quality of life is affected by the child's health state. These data were obtained from multiple sources described below (and in Table 12). The model was constructed in TreeAge Pro (version 2016; Williamstown, MA: TreeAge Software, Inc.).

Transition probabilities

For the ForsythKids arm, the annual age-specific probabilities of developing dental caries were obtained directly from the 6-year results of the program (Appendix B). Repeat filling probabilities were also obtained from the program's data and were estimated to be 0.0371. Additionally, we estimated a constant probability of 0.95 of having a filling conditional on a decayed molar. In the Forsythkids program, the data indicated no emergency room visits due to dental reasons.

The probabilities for the standard dental care arm were obtained from a cross-sectional national survey – NHANES (Appendix B).[97] To obtain age- and tooth-specific decay probabilities, we executed a series of logistic regressions with the decayed tooth as the dependent variable and adjusting for age and poverty income ratio. Since NHANES is not a longitudinal survey, we assumed that young children would end up experiencing dental decay similarly to their older peers. Further, using data from medical health services utilization released by the US department of commerce,[99] we estimated that each child had an average of 0.63 annual visits to the dentist in the standard dental care arm. Also, we estimated a constant probability of having secondary decay after filling of 0.03[100] for the standard dental care arm; and, based on a policy brief released by the ADA, a probability of visiting the ER due to dental reasons of 0.003 was estimated.[101]

Costs

Costs were estimated from the societal perspective (including all costs regardless who pays). Cost categories included direct dental costs (dental personnel salaries, treatment materials, and equipment costs) and direct non-dental costs (purchasing software and license for electronic dental records and training to use the system, transportation and printing costs) (Table 13). We assumed no indirect costs due to work loss or travel time of the parents, since the schoolchildren received dental care within school hours and were away from the class for no more than 25 minutes.

Treatment costs for the ForsythKids Program were estimated from records obtained from the program manager. The hours spent by dentists, hygienists and assistants were monetized using salary data from the U.S. bureau of labor statistics.[102] All costs were converted to 2015 prices using the consumer price index (CPI).[103]

Health utilities

To reflect the reduced quality of life in patients with dental decay, health utility weights were assigned to each health state (Table 12).[104] The expected number of QALYs per tooth over 6 years was calculated by multiplying the weight of the health state by the time spent in that particular health state and summed over all health states and years. After that, the expected number of QALYs per student over 6 years was the average of QALYs over all teeth.

Disease-specific outcome

As a disease-specific outcome we estimated the number of years that posterior permanent molars remained sound over the length of the time horizon. Sound teeth were defined as not being decayed or filled. In order to calculate this, we created a tracker variable that counts the length of time a tooth has spent in the health state 'Sound'.

Base-case analysis

In the base-case analysis, 1,585 children had two annual visits; compromising a total of 3,710 visits annually to the ForsythKids program leading to an annual cost of $520 per child (Table 13). Further, one dentist, three dental hygienists, and four dental assistants participated in each school visit, each visit took 15 minutes, and that the program had a separate manager.

Sensitivity Analysis

One of the major challenges facing such preventive programs is achieving high participation rate, which in turn affects the efficiency resource allocation. Therefore, after consulting with the program manager, we estimated that the maximum number of students that could be seen twice annually is 5,184 children comprising a total of 10,368 visits annually. This in turn led to reduction in annual cost per child from $520 to $186.

Further, based on the program's manager estimations, each hygienist was able to see 24 children a day, provided that she spent 15 minutes per child and was in the school for 6 hours. Consequently, based on these calculations, one hygienist can see approximately 1,585 children twice a year. Therefore, assuming that only one dentist, one hygienist, and two dental assistants compose the dental team led to a reduction of annual cost per child to $394.

Additionally, an examining dentist could potentially run the program; therefore, to address such uncertainty we ran the model while leaving the manager salary out assuming that the examining dentist would run the program. Again this led to reduction in annual cost per child from $520 to $420.

Since 90% of dental decay is concentrated in the pits and fissures of posterior teeth, several dental prevention programs may choose to place sealants only on the first permanent molars or to place sealants on first and second permanent molars. Moreover, the probability of developing dental decay on anterior dentition, specifically in this age group, is very low (less than 1%).[105] Therefore, we have evaluated the program's effectiveness on 1st permanent molars only, both 1st and 2nd permanent molars, and all posterior teeth except wisdom teeth.

Finally, prevention programs are known to influence longer-term risk of dental decay, far after a patient stops participating.[106, 107] Therefore, we obtained the 15-years odds of developing dental decay on sealed molars from the literature,[108] then we transformed the odds into probability from which we obtained the annual rate. Finally, we used these annual rates to extrapolate over 10 and 20 years. Consequently, we also report on cost-effectiveness over a 10- and 20-year time horizons.

Cost-effectiveness Analysis

The cost-effectiveness of the ForsythKids Program compared with standard dental care was expressed as an incremental cost-effectiveness ratio (ICER). The ICER is defined as the additional cost divided by the additional health benefit of the more effective program. The cost-effectiveness of the ForsythKids Program is determined by comparing the ICER to an external standard of what society is willing to pay for one QALY gain i.e., the societal willingness to pay (WTP). The ICER was obtained after running 1,000,000 children through each submodel. Costs and health-related benefits were discounted by an annual rate of 3%.[109]

Overall, parameter uncertainty was evaluated by conducting probabilistic sensitivity analysis (PSA). Through PSA, we have assigned distributions to the parameters in the model. Since costs are usually positively skewed, we used a Gamma distribution to model all costs to account for such skewedness. Since health utilities are bounded between 0 and 1, we used a beta distribution. Random sampling from these distributions was undertaken (i.e., second order Monte Carlo simulation) and replicated 100,000 times. The average costs and QALYs across all 100,000 simulations were used to report the ICER. After that, using data obtained from the PSA, cost-effectiveness acceptability curves were created to display the proportion of simulations that was cost-effective at a certain WTP value indicating the uncertainty in the decision to adopt one program over the other.

Results

In the base-case analysis, the discounted mean costs over a 6-year time horizon were $2,954 per child for the ForsythKids program and $1,064 per child for the standard dental care program. The mean health benefits in terms of QALYs were 5.5329 per child for the ForsythKids Program and 5.4862 per child for the standard dental care. In total, in the ForsythKids arm, permanent molars had a mean of 5.8 sound tooth years. For the standard care arm, the mean of number of sound tooth years was 5.6. The ForsythKids Program was more expensive ($1,889 additional costs) and more effective (0.0467 additional QALYs) compared with standard dental care resulting in an ICER of $40,454 per QALY (Table 14) and $1,093 per one additional sound tooth year (Table 15).

Varying the number of enrolled children (i.e., assuming an annual number of visits of 10,368) led to a significant change, both in terms of cost per QALY and cost per one additional sound tooth year, resulting in the ForsythKids *dominating* (i.e., being more effective and less costly) than the standard dental care.

Under the assumption that the dental team is composed of one dentist, one hygienist, and two dental assistants, the ICER was reduced to $26,662 per QALY and $655 per one additional sound tooth year. Additionally, when the program is assumed to be run by the examining dentist, the ICER was reduced to $27,424 per QALY and $741 per one additional sound tooth year.

Limiting effectiveness estimates to first permanent molars or all posterior teeth resulted in ICERs of \$19,880 per QALY and \$81,601 per QALY, respectively (Table 14). The cost per one additional sound tooth year was estimated to be \$1,200 and \$1,079, respectively (Table 15).

When extrapolating over a longer time horizon of 10 and 20 years, in terms of cost per QALY, ICERs of \$28,646 and \$27,024 per QALY were estimated, respectively (Table 16). In terms of cost per one additional sound tooth year, a cost of \$691 and \$405 was estimated, respectively (Table 17).

The Forsythkids was optimal in 75% and 98% of the 100,000 simulations in PSA using a societal willingness to pay (WTP) threshold of \$50,000 per QALY and \$100,000 per QALY, respectively, compared to standard dental care (Figure 2).

Discussion

Using a trial-based data and population-based data from the NHANES, we conducted a dental decay initiation and progression simulation model for children in the ForsythKids program and found that, using a societal WTP threshold of $50,000, the ForsythKids may be a successful tool in reducing or eliminating the inequalities in access to care among children from low SES families. Under base-case assumptions, the ForsythKids resulted in higher QALYs, number of sound tooth years, and costs resulting in an ICER of $40,454 per QALY; and, at the tooth-level, an ICER of $1,093 per sound tooth year. There were fixed costs associated with bringing the providers and equipment to the schools, other than consumable costs. Therefore, the ForsythKids was dominating the standard dental care (cheaper and more effective) – when increasing number of enrolled children.

The results seem sensitive to reducing number of dental personal (i.e. hiring one dental hygienist instead of three); and whether the program had a manager or the examining dentist run it. ICERs were more favorable under the assumption of hiring only one dental hygienist suggesting that hiring dental personnel based on participation rates could be an efficient way to improving the program's cost-effectiveness.

To our knowledge the only attempt to evaluate comprehensive school-based dental prevention programs was executed in 1985, over a 4-year time horizon, in a comprehensive school-based dental prevention program, Klein et.al[1] reported that the only effective intervention was sealants application. Further, they concluded that, though it is effective, it is not a cost-effective intervention. They reached this conclusion by crudely comparing the cost of sealant application per tooth ($23, 1981) vs. cost of restoration per tooth ($19.92, 1981). However, after accounting for effectiveness of preventive measures provided in the ForsythKids program, it is clear that our conclusion does not support Klein's et al. conclusions.

More recently, in 1993, Weintraub et.al[96] conducted a retrospective study to evaluate sealants cost-effectiveness vs. no sealants and reported an ICER of $82 (1985). Adjusting for inflation using average CPI values, this translates into $180.6 per additional sound tooth year, over 11-year time horizon. Conversely, our estimate was much higher, $691 per additional sound tooth year. This inconsistency could be due to several factors. Particularly, Weintraub et.al *did not* 1) expand their evaluation beyond 1st permanent molars; 2) use Medicaid costs; 3) account for waste time; and 4) performed their analysis from a payer perspective. Additionally, our estimates could be underestimated (higher ICER) since we did not account for indirect costs in the standard dental care arm. Therefore, after accounting for waste time by reducing number of dental hygienists to one and assuming indirect costs (50% of direct costs)[1, 110] in the standard dental care arm and Weintraub's estimate, we estimate ICERs of $273 and $272 (in 2015 dollars) per additional sound tooth year for the ForsythKids and Weintraub et al, respectively, thus supporting the positive cost-effectiveness findings of Weintraub et al.

Cost-effectiveness analysis of preventive intervention, on the short term, tends to be unfavorable since the costs of the intervention occur instantly. While the costs of not providing the intervention usually are delayed until disease initiation. Consistently, estimates from this study show that, despite being cost saving under some assumptions, the ICERs tend to be more favorable over time (10-year ICERs of $28,646 per QALY and $691 per additional sound tooth year; and 20-year ICERs of $27,024 per QALY and $405 per additional sound tooth year). Therefore, preventing dental caries reduces the future costs of dental care for children.

Since there were fixed costs for bringing the providers and equipment to the schools, it might be assumed that providing full-mouth exams and preventive care is cost-effective. However, fixing the costs while changing the effectiveness to account for all posterior teeth, led to inflate the ICER to be $81,601 per QALY, suggesting that it may not be cost-effective at a societal WTP of $100,000. On the other hand, fixing the costs while accounting for the effectiveness on the 1st permanent molars reduced the ICER to $19,880 per QALY. Therefore, since strategies lower than a specific WTP threshold are generally considered cost-effective, it might be safe to say that these variations are cost-effective at a WTP of $100,000. However, because the 'most cost-effective' strategy is the one with the highest ICER below the threshold (because it provides the highest benefits for the cost), it appears that treating permanent molars is the most cost-effective method at a WTP of $50,000. Whereas, at a WTP of $100,000, treating all posterior teeth seems to be the most cost-effective strategy.

The use of quality adjusted life year (QALY) is well established in the medical literature and measured at the subject-level. A dental analogous to QALY is quality adjusted tooth year (QATY) and measured at the tooth-level.[111] We couldn't report our results in terms of cost per

QATY because we couldn't get the exact cost per tooth. However, assuming that the cost for anterior teeth in the ForsythKids arm is negligible, the probability of dental caries on anterior teeth is negligible, and the cost per tooth is equal the cost per child divided by 16, number of posterior teeth excluding wisdoms, an ICER of $256 per QATY was estimated. Further, for the standard of care arm, if we assume an indirect cost of 50% of the direct costs then the ICER dropped to $184 per QATY. Finally, including the indirect costs and assuming that the dental team had one dental hygienist instead of three dental hygienists, an ICER of $81 per QATY was estimated.

This study has several limitations. First, the inherent limitation of being a simulation model that requires combining data from multiple sources. However, we attempted to address this limitation via a series of sensitivity analyses along with PSA. Second, our study population data came from mainly a disadvantaged population – low SES group. Therefore, it may not be applicable for other types of population or generalizable to all schoolchildren. Third, our ICERs maybe underestimated (higher than it should be) since we didn't account for the real indirect costs in the standard dental care arm. Nonetheless, we attempted to adjust for this in one of our sensitivity analysis assuming that indirect cost is 50% of the direct one.

While this study has several limitations, a primary strength was to use the state-of-the-art methodology to combine a pragmatic trial-based data along with external data to evaluate the cost-effectiveness of the ForsythKids program. Therefore, the primary data did actually help in informing the input parameters in our analyses and consequently reducing uncertainty sources.

In conclusion, in terms of cost per QALY and cost per additional sound tooth-year, the ForsythKids program seems cost-effective compared with standard dental care and represents good value for money both on the short and longer term. This indicates that the ForsythKids (a comprehensive package of preventive dentistry technologies) may potentially be a successful tool in reducing or eliminating the inequalities in access to care among children from low SES families while improving their health status.

Discussion and Conclusion

In a sample of more than 30 Title 1 schools in the Boston area, baseline dental decay prevalence was approximately double the national average. However, this high prevalence was not due to access to dental care issues, since all the schools were within one to eight blocks away from a federally qualified health care center or a dental school. Longitudinally, each subsequent visit to the ForsythKids program was associated with almost flat (0.11% to 0.3%) trend in the proportion of sound teeth or surfaces remaining sound over visits. Further, compared with standard dental care, on permanent molars level, the ForsythKids program appeared to be cost effective, indicating good value for cost at a societal willingness to pay threshold of $50,000. However, in the U.S., there is no consensus between economists or a regulating authority to decide what this threshold should be. In the U.K., the National Institute of Clinical Excellence obviously adopts a £30,000 ($42,437) threshold to indicate whether an intervention is cost effective or not.[112] Moreover, Braithwaite et.al suggests a lower bound of $113,000, after reviewing the medical expenditures among U.S. citizens since 1950.[112]

Although the dataset has imperfections that were discussed earlier, we conducted several sensitivity analyses to assess the robustness of our results to the study limitations. These analyses provided no evidence that argue against the program's apparent preventive effect.

Although the schools tried to improve participation rates by distributing consent forms along with other school documents, the participation rates were still very low. However, traditional active consent, through which parents must sign a form to "opt in" to programs, results in multiple opportunities for omission, such as misplaced forms, even among parents interested in the program.[82] Alternative approaches to consent, such as passive consent—in which all children are included unless parents refuse care (i.e., "opt out")—may be more effective in increasing participation rates.

In conclusion, these data are consistent with the hypothesis that the ForsythKids program prevents new dental decay in school children, and that the program provides good value for the benefits acheived. Indeed, it appeared to be cost saving (dominating) in some situations, depending on the number of enrolled children. Finally, because there are fixed costs of bringing care to each school, improving participation rates can only improve the cost effectiveness of such a program.

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Table 1: Distribution of community-based dental programs among states by type of services delivered (2009).[113]

State	No. of dental programs with ***education*** services only	No. of dental programs with ***preventive*** services only	No. of dental programs with ***preventive and therapeutic*** services
Alabama	0	0	7
Alaska	0	0	2
American Samoa *			
Arizona	3	2	3
Arkansas	0	1	0
California	0	34	0
Colorado	0	9	6
Connecticut	0	2	5
Delaware	1	1	0
District of Columbia	2	0	2
Florida	21	7	49
Georgia	0	0	58
Guam *			
Hawaii	0	0	0
Idaho	0	7	0
Illinois	33	21	31
Indiana	93	2	4
Iowa	24	24	2
Kansas	0	2	2
Kentucky	0	0	8
Louisiana	0	2	1
Maine	0	3	0
Maryland	1	5	12
Massachusetts	2	10	3
Michigan	1	2	14
Minnesota	NA	NA	NA
Mississippi	0	1	1
Missouri	1	4	4
Montana	0	0	0
N. Mariana Islands *			
Nebraska	NA	NA	NA
Nevada	1	3	4
New Hampshire	1	22	5
New Jersey	16	0	8
New Mexico	0	0	0
New York	0	58	17
North Carolina	0	0	50
North Dakota	3	3	0
Ohio	0	12	19
Oklahoma	0	29	9

Oregon	2	5	4
Pennsylvania	0	0	3
Puerto Rico *			
Republic of Palau *			
Rhode Island	0	0	1
South Carolina	1	6	3
South Dakota	0	0	1
Tennessee	0	0	61
Texas	NA	NA	NA
Utah	11	2	1
Vermont	12	0	0
Virgin Islands *			
Virginia	1	4	39
Washington	0	27	0
West Virginia	2	6	2
Wisconsin	0	68	3
Wyoming	NA	NA	NA

(*) No data for 2009.
(NA) This question was not answered.

Table 2: Extent of different dental programs across states (2009)[113]

Program	Number of states	Number of people served
Dental screening	27	1,440,182
Oral hygiene education	26	1,283,576
Oral health survey	23	205,327
Sealants	32	489,819
Fluoride mouth-rinse	28	800,899
Fluoride varnish	15	258,878
Fluoride supplements	7	169,805
Early childhood caries	15	279,505

Table 3: Description of types of school-based oral health programs and necessary resources for.

Program	Description	Equipment and resources needed
Screening & oral hygiene education	Dental personal do a visual exam Parents informed about their child's oral heath status A referral to dental care usually provided	No dental equipment needed
Fluoride programs		
Rinse	No water fluoridation, rinse daily or weekly depending on available resources	
Tablet	No water fluoridation, swallowed on daily basis	No dental equipment needed
Varnish	All settings, a varnish that is applied to teeth by dental professional twice a year	
Sealants	All settings, dentist or hygienist provide the sealant as needed	Dental chair, light, curing light, suction unit compressor, and water
Comprehensive programs	All settings, dentist or hygienist provide the services as needed after the initial dental exam	Similar to sealant programs, in case it is decided to place ART*

* ART is defined as Atraumatic Restorative Treatment.

Table 4: Efficacy of various preventive oral health interventions.

Intervention	Tested frequency	Estimated efficacy (%)	Source
Fluoride toothpaste	Twice a day	20 to 40	Meta analysis[114], Cochrane review[115]
Fluoride varnish	At least twice a year	40	Cochrane review[47]
Silver fluoride	Twice a year	80	Randomized controlled trial[116], systematic review[93], randomized controlled trial[117]
Sealants	Once for pits & fissures	80	Cochrane review[46], systematic review[118], meta analysis[119]
ART*	As needed	80	Meta analysis[70], systematic review[118], Cochrane review[120], meta analysis[121]

* ART is defined as Atraumatic Restorative Treatment.

Table 5a: The 33 schools participated in the ForsythKids and included in the analytic set, by year and town

School Name	First Visits	Town or City
COBBETT	Spring 2004	Lynn
HARRINGTON	Spring 2004	Lynn
HYANNISEAST	Spring 2004	Hyannis
HYANNISWEST	Spring 2004	Hyannis
FARRAGUT	Spring 2005	Boston
TOBIN	Spring 2005	Boston
NANTUCKET ELEMENTARY	Spring 2007	Nantucket
ABORN	Fall 2007	Lynn
BRICKETT	Fall 2007	Lynn
CALLAHAN	Fall 2007	Lynn
CHATHAM	Fall 2007	Chatham
CONNERY	Fall 2007	Lynn
DREWITZ	Fall 2007	Lynn
EASTHAM	Fall 2007	Eastham
EDDY	Fall 2007	Brewster
FORD	Fall 2007	Lynn
HOOD	Fall 2007	Lynn
LINCOLN THOMPSON	Fall 2007	Lynn
ORLEANS	Fall 2007	Orleans
QUASHNET	Fall 2007	Mashpee
SANDWICH-FORESTDALE	Fall 2007	Sandwich
SEWELL ANDERSON	Fall 2007	Lynn

SHOEMAKER	Fall 2007	Lynn
STONYBROOK	Fall 2007	Brewster
TRACY	Fall 2007	Lynn
WELLFLEET	Fall 2007	Wellfleet
EZRA BAKER	Spring 2008	West Dennis
LAURENCE MACARTHUR	Spring 2008	South Yarmouth
STATION AVENUE	Spring 2008	South Yarmouth
KENNETH C. COOBMS	Fall 2008	Mashpee
ME SMALL	Fall 2008	West Yarmouth
HENRY T WING	Fall 2008	Sandwich
INGALLS	Fall 2008	Lynn

Table 5b: Participation rates for each grade over the program time period (2004-2010) for children enrolled in Title 1 schools in Massachusetts, receiving comprehensive dental preventive care through the ForsythKids.

Visit year	(Grade)							
	(K)	(1st)	(2nd)	(3rd)	(4th)	(5th)	(6th)	Total
	N	N	N	N	N	N	N	N
2004	9	136	189	175	100	38	18	665
2005	4	120	141	113	64	8	2	452
2006	5	78	53	50	14	10	2	212
2007	244	346	300	257	222	149	65	1,583
2008	315	369	358	314	261	175	126	1,918
2009	361	424	278	215	187	141	106	1,712
2010	74	125	71	62	72	45	46	495
Total enrolled in that grade in the ForsythKids	1,012	1,598	1,390	1,186	920	566	365	7,037
Total enrolled in that grade in the 33 schools	7,339	8,594	8,989	8,174	6,698	5,707	1,204	46,705
Participation rate (%)	13.79%	18.59%	15.46%	14.51%	13.74%	9.92%	30.32%	15.07%

Data Source: U.S. Department of Education, National Center for Education Statistics.[78]

Table 6: Baseline demographic characteristics of children enrolled in Title 1 schools in Massachusetts, receiving comprehensive dental preventive care through the ForsythKids.

Characteristic	All participants		First six schools		Remaining schools	
	N	%	N	%	N	%
Total	6,828	100.00%	2,589.00	37.92%	4,239.00	62.08%
Gender						
Male	3,450.00	50.50%	1,272.00	49.13%	2,178.00	51.38%
Female	3,285	48.10%	1,286.00	49.67%	1,999.00	47.16%
Missing	93	1.40%	31.00	1.20%	62.00	1.46%
Race						
Black/African American	392	5.70%	172.00	6.64%	220.00	5.19%
White	1,173	17.20%	173.00	6.68%	1,000.00	23.59%
AI/AN/Hawaiian/PI	50	0.70%	9.00	0.35%	41.00	0.97%
Asian	227	3.30%	56.00	2.16%	171.00	4.03%
More than one race	280	4.10%	81.00	3.13%	199.00	4.69%
Don't know, no answer, missing	4,706	68.90%	2,098.00	81.04%	2,608.00	61.52%
Age at entry						
5	970	14.20%	254.00	9.81%	716.00	16.89%
6	1,556	22.80%	669.00	25.84%	887.00	20.92%
7	1,356	19.90%	624.00	24.10%	732.00	17.27%
8	1,155	16.90%	502.00	19.39%	653.00	15.40%
9	895	13.10%	335.00	12.94%	560.00	13.21%
10	551	8.10%	130.00	5.02%	421.00	9.93%
11	278	4.10%	62.00	2.39%	216.00	5.10%
12	67	1.00%	13.00	0.50%	54.00	1.27%

Table 7: Baseline dental health and care indicators for children enrolled in Title 1 schools in Massachusetts, receiving comprehensive dental preventive care through the ForsythKids.

Dental health indicators	Total		First six schools		Remaining schools	
	N	%	N	%	N	%
Total	6,828.00	100	2,589.00	37.92%	4,239.00	62.08%
Children with at least one decayed or filled tooth						
No	3,036	44.5	980.00	37.85%	2,056.00	48.50%
Yes	3,792	55.5	1,609.00	62.15%	2,183.00	51.50%
Children with at least one decayed tooth						
No	4,543	66.5	1,528.00	59.02%	3,015.00	71.13%
Yes	2,285	33.5	1,061.00	40.98%	1,224.00	28.87%
Children with at least one adult decayed tooth						
No	6,191	90.7	2,152.00	83.12%	4,039.00	95.28%
Yes	637	9.3	437.00	16.88%	200.00	4.72%
Children with at least one deciduous decayed tooth						
No	4,837	70.8	1,694.00	65.43%	3,143.00	74.14%
Yes	1,991	29.2	895.00	34.57%	1,096.00	25.86%
Children with at least one filled tooth						
No	4,147	60.7	1,484.00	57.32%	2,663.00	62.82%
Yes	2,681	39.3	1,105.00	42.68%	1,576.00	37.18%
Children with at least one sealed tooth						
No	3,995	73.86	1,693.00	65.39%	2,302.00	54.31%
Yes	2,833	26.14	896.00	34.61%	1,937.00	45.69%
Children with at least one treated tooth						
No	2,669	39.1	1,066.00	41.17%	1,603.00	37.82%
Yes	4,159	60.9	1,523.00	58.83%	2,636.00	62.18%

Table 8: Baseline Decayed Filled Surfaces (DFS) scores and Significant caries Index (SiC) cutoff, for children enrolled in Title 1 schools in Massachusetts, receiving comprehensive dental preventive care through the ForsythKids.

Index	Total	First six schools	Remaining schools
Permanent dentition			
DFS	0.509	0.817	0.284
SiC	1.525	2.447	0.851
Primary dentition			
dfs	2.685	3.475	2.113
SiC	7.48	9.217	5.924

Table 9: Mean DFS and dfs scores with proportion of dfs and DFS – over visits, among children enrolled in Title 1 schools in Massachusetts, receiving comprehensive dental preventive care through the ForsythKids.

Visit number, within subject	Mean DFS	Mean DFS/No. of adult surfaces	Mean dfs	Mean dfs/No. of deciduous surfaces
1	0.54	1.1%	2.85	6.8%
2	0.69	1.2%	3.58	9.4%
3	1.02	1.6%	4.08	12.2%
4	1.06	1.5%	4.08	13.0%
5	1.05	1.5%	4.23	14.9%
6	1.20	1.7%	4.05	16.3%

Table 10: Average estimated proportion of sound surfaces remaining sound, average estimated proportion of sound teeth, average estimated proportion of sound smooth surfaces remaining sound, and average proportion of sound occlusal surfaces remaining sound – over visits, among children enrolled in Title 1 schools in Massachusetts, receiving comprehensive dental preventive care through the ForsythKids.

Visit number, within subject	Proportion of sound teeth remaining sound	Proportion of sound surfaces remaining sound	Proportion of sound smooth surfaces remaining sound	Proportion of sound occlusal surfaces remaining sound
All dentition				
2	96.4%	98.6%	98.9%	97.2%
3	96.8%	98.8%	99.1%	97.4%
4	97.2%	98.9%	99.2%	97.7%
5	97.7%	99.1%	99.3%	98.0%
6	98.1%	99.2%	99.4%	98.3%
Adult dentition				
2	98.6%	99.6%	99.7%	98.9%
3	98.7%	99.6%	99.7%	99.0%
4	98.8%	99.6%	99.7%	99.1%
5	98.9%	99.6%	99.7%	99.2%
6	99.1%	99.7%	99.7%	99.4%
Deciduous dentition				
2	93.6%	97.5%	98.0%	95.1%
3	93.7%	97.5%	98.0%	95.0%
4	94.1%	97.6%	98.1%	95.2%
5	94.4%	97.6%	98.1%	95.2%
6	94.7%	97.7%	98.2%	95.3%

Table 11: Estimated per-visit change in the proportion of sound surfaces remaining sound over visits, sound teeth remaining sound over visits, sound smooth surfaces remaining sound over visits, and sound occlusal surfaces remaining sound over visits among children enrolled in Title 1 schools in Massachusetts, receiving comprehensive dental preventive care through the ForsythKids.

Baseline decay	Proportion of sound teeth remaining sound	Proportion of sound surfaces remaining sound	Proportion of sound smooth surfaces remaining sound	Proportion of sound occlusal surfaces remaining sound
All dentition				
Marginal (all children) trends	0.30%	0.11%	0.08%	0.22%
95% C.I.	(0.19%, 0.42%)	(0.07%, 0.15%)	(0.04%, 0.12%)	(0.12%, 0.32%)
P value	<0.0001	<0.0001	<0.0001	<0.0001
Trends in kids with no baseline decay	0.05%	0.00%	0.00%	-0.02%
95% C.I.	(-0.06%, 0.16%)	(-0.04%, 0.04%)	(-0.03%, 0.04%)	(-0.1%, 0.07%)
P value	0.368	0.909	0.912	0.65
Trends in kids with baseline decay	0.80%	0.33%	0.24%	0.71%
95% C.I.	(0.56%, 1.03%)	(0.23%, 0.42%)	(0.15%, 0.32%)	(0.5%, 0.9%)
P value	<0.0001	<0.0001	<0.0001	<0.0001
Adult dentition				
Marginal (all children) trends	0.15%	0.04%	0.01%	0.15%
95% C.I.	(0.07%, 0.24%)	(0.01%, 0.07%)	(-0.01%, 0.04%)	(0.08%, 0.23%)
P value	<0.0001	0.007	0.285	<0.0001
Trends in kids with no baseline decay	0.07%	0.02%	0.01%	0.06%
95% C.I.	(-0.02%, 0.16%)	(-0.01%, 0.05%)	(-0.02%, 0.03%)	(-0.02%, 0.14%)
P value	0.122	0.217	0.59	0.156
Trends in kids with baseline decay	0.32%	0.08%	0.03%	0.33%
95% C.I.	(0.15%, 0.48%)	(0.02%, 0.14%)	(-0.03%, 0.08%)	(0.18%, 0.48%)
P value	<0.0001	0.007	0.326	<0.0001
Deciduous dentition				
Marginal (all children) trends	0.49%	0.16%	0.12%	0.28%
95% C.I.	(0.19%, 0.8%)	(0.04%, 0.3%)	(0.00%, 0.23%)	(0.02%, 0.53%)
P value	0.002	0.01	0.043	0.033
Trends in kids with no baseline decay	0.35%	0.13%	0.12%	0.17%
95% C.I.	(0.07%, 0.64%)	(0.04%, 0.23%)	(0.03%, 0.2%)	(-0.08%, 0.42%)
P value	0.016	0.007	0.008	0.175
Trends in kids with baseline decay	0.76%	0.21%	0.12%	0.50%
95% C.I.	(0.1%, 1.4%)	(-0.07%, 0.49%)	(-0.14%, 0.39%)	(-0.06%, 1.1%)
P value	0.023	0.136	0.363	0.082

Table 12: Model variables with base-case values and values used for sensitivity analyses.

Variable	Base-Case Value	Sensitivity Analysis	Probabilistic distribution for sensitivity analyses	Source
Age (Years)	6	NA	NA	NA
Discount rate (%)	3	NA	NA	Weinstein MC et.al[109]
Annual cost per child at the Forsythkids arm (FK)	$520	$150* $185** $420***	Gamma	Program
Annual cost per child at standard care arm (SC)	$191.02	--	Gamma	AHRQ[122]
Restoration cost at FK	$3.30	--	Gamma	Program
Restoration cost at SC	$58	--	Gamma	Medicaid[123]
Emergency department (ER) visit cost	$718	--	Gamma	Wall T et.al[101]
Utility of decayed tooth	0.66	--	Beta	Fyffe HE et.al[104]
Utility of temporary filled tooth FK	0.78	--	Beta	Fyffe HE et.al[104]
Utility of permanent filled tooth SC	0.81	--	Beta	Fyffe HE et.al[104]
Probability of filling a decayed tooth at FK	95%	--	NA	Program
Probability of filling a decayed tooth at SC	61%	81%	NA	Assumed
Probability of failed restoration at FK	3.71%	--	NA	Program
Probability of failed restoration at SC	3%	--	NA	Manhart J et.al[100]
Probability of ER visit at FK	0	--	NA	Program
Probability of ER visit at SC	0.3%	--	NA	Wall T et.al[101]

* Assuming 10,368 children visits annually and that the program run by the examining dentist.
** Assuming 10,368 children visits annually and that the program run by a separate manager.
*** Assuming 3,710 children visits annually and that the program run by the examining dentist.

Table 13: Implementation costs for ForsythKids program.

Cost Category	Amount	% Of Total	Assumptions
Salaries			
Program Manager	$116,667.00	11.9%	60% of effort and 10 Mo/year
Business Manager	$66,667.00	6.8%	100% of effort and 10 Mo/year
Dentist	$128,867.00	13.5%	One dentist 10 Mo/year
Hygienist	$178,800.00	18.8%	Three RDH 10 Mo/year
Assistant	$88,476.00	12.4%	Four DA 10 Mo/year
Fringe 30%	$117,968.00	19.0%	
Equipment			
Van	$6,000.00	0.6%	5 year life span
Portable equipment	$11,598.50	1.3%	5 year life span
Consumables			
Travel	$3,000.00	0.4%	Gas, tolls, insurance
Program's supplies	$55,650.00	5.7%	Per child per visit (3,710 annual visits)
Software	$5,000.00	0.5%	5 year life span
Electronic records	$3,000.00	0.3%	5 year life span
Indirect costs			
Overhead	$86,844.83	8.9%	Printing costs, office work
Total annual	$924,413.43	100.0%	With managers salaries
	$741,079.43		NO managers salaries
Six-year total	$5,546,480.58		With managers salaries
	$4,446,476.58		NO managers salaries
Cost per child per visit	$259.55		With managers salaries
	$210.12		NO managers salaries
	$92.86		With managers salaries
	$75.18		NO managers salaries

Table 14: Six-year quality-adjusted life year (QALYs), costs ($), and incremental cost effectiveness ratio ($/QALY)

Strategy	QALYs	Costs	ICER
1st molars			
Standard care	5.3928	$1,064	Reference
ForsythKids	5.4862	$2,954	$19,880
All molars (base-case)			
Standard care	5.4863	$1065	Reference
ForsythKids	5.5330	$2,954	$40,454
All posterior teeth			
Standard care	5.5330	$1,065	Reference
ForsythKids	5.5563	$2,954	$81,601

Table 15: Six-year cumulative years of survival, costs, and incremental cost effectiveness ratio ($/sound tooth year)

Strategy	Cumulative years of survival	Costs	ICER
1st molars			
Standard care	20.9	$1,064	Reference
ForsythKids	22.4	$2,954	$1,200
All molars (base-case)			
Standard care	44.6	$1,065	Reference
ForsythKids	46.3	$2,954	$1,093
All posterior teeth			
Standard care	92.6	$1,065	Reference
ForsythKids	94.3	$2,954	$1,079

Table 16: 10 and 20 years quality-adjusted life year (QALYs), Costs ($), and incremental cost effectiveness ratio ($/QALY)

Strategy	QALYs	Costs	ICER
10 year results			
Standard care	8.5145	$1,679	Reference
ForsythKids all molars	8.6161	$4,589	$28,646
20 year results			
Standard care	14.2765	$3,011	Reference
ForsythKids all molars	14.4690	$8,214	$27,025

Table 17: 10 and 20 years cumulative years of survival, costs, and incremental cost effectiveness ratio ($/sound tooth year)

Strategy	Cumulative years of survival	Costs	ICER
10 year results			
Standard care	69.4	$1,679	Reference
ForsythKids all molars	73.6	$4,589	$691
20 year results			
Standard care	105.5	$3,011	Reference
ForsythKids all molars	118.4	$8,214	$405

Figure 1: Illustration of the micro-simulation decision tree. The expanded node summarizes the structure of each of the eight independent Markov submodels.

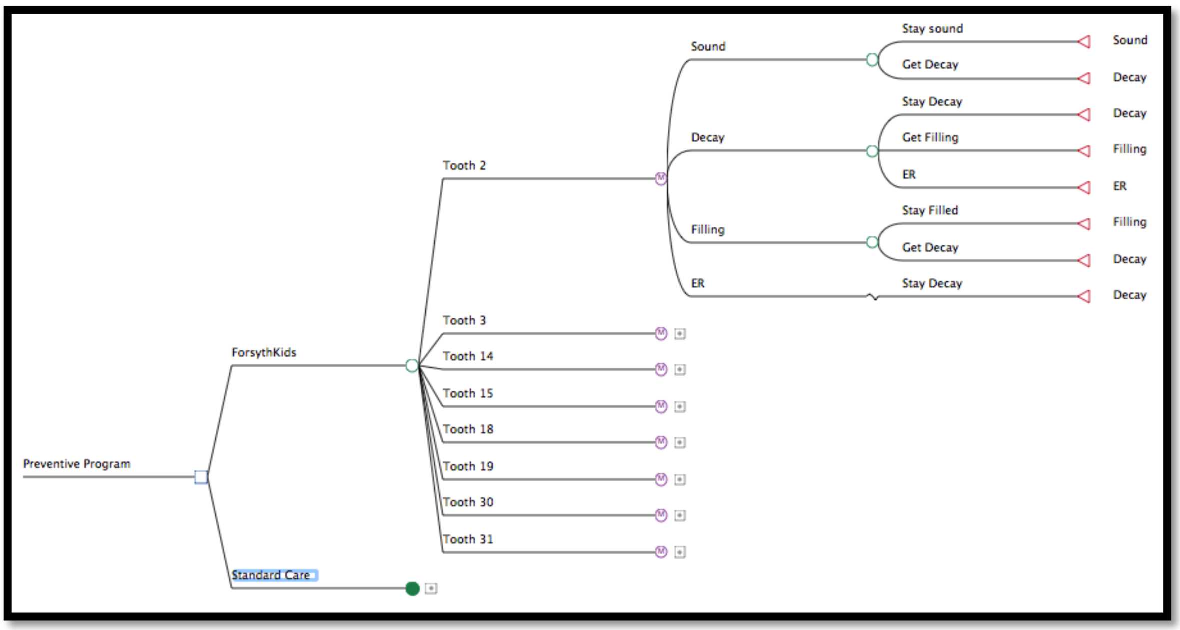
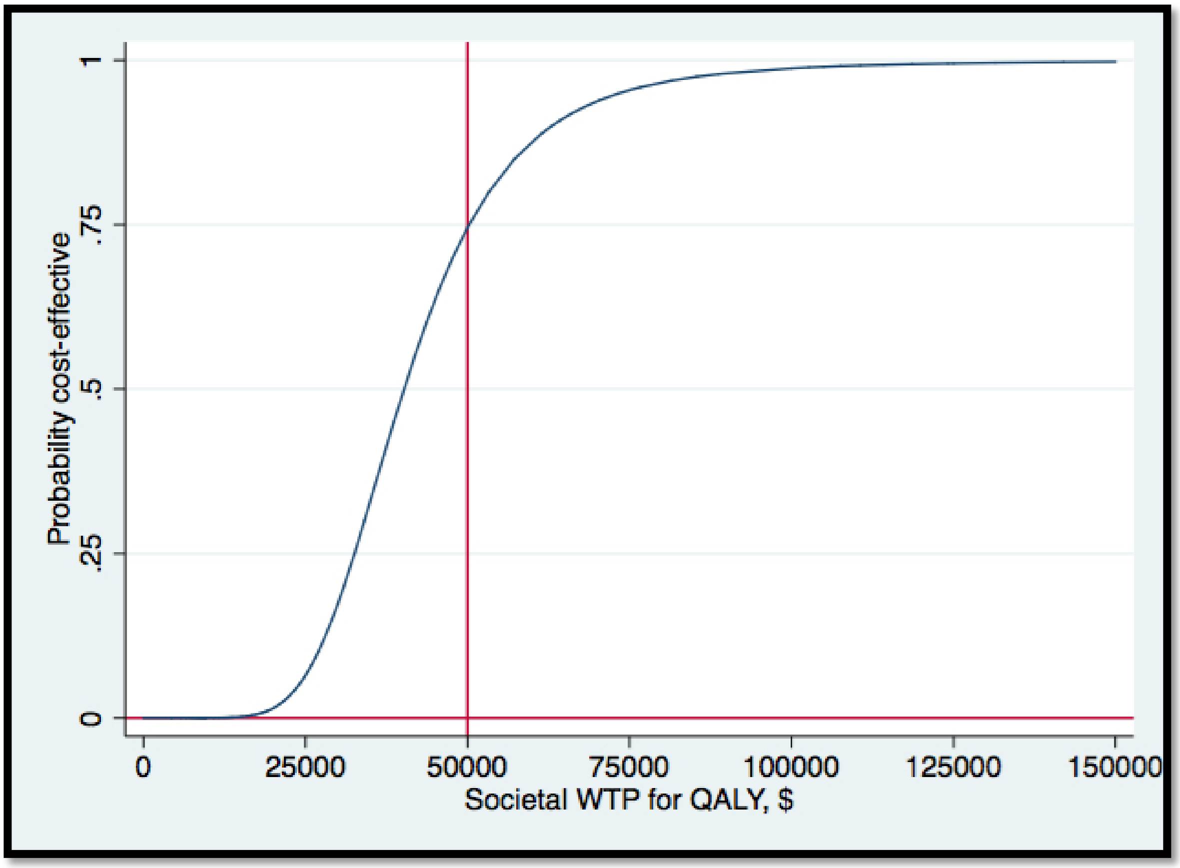


Fig 2: Base-case cost-effectiveness acceptability curve showing the probability of the Forsythkids being cost effective at different values of societal willingness to pay (WTP) per quality adjusted life year (QALY).



Appendix A

Guidelines and Recommendations about Preventive Dentistry

CDC on Sealants[40]

1. Seal sound non-cavitated pit and fissure surfaces of posterior teeth, highest priority to first and second permanent molars.
2. Differentiate cavitated and non-cavitated lesions as following:
    a. Unaided visual assessment is adequate.
    b. Dry teeth before assessment.
    c. An explorer may be used, gently, to confirm cavitation. Do not use sharp explorer under force.
    d. Radiographs are unnecessary for sealant placement.
    e. Any other diagnostic technologies are not required.
3. Clean teeth surface as following:
    a. Toothbrush prophylaxis is acceptable.
    b. Additional surface preparation methods, such as enameloplasty, are not required.
4. Use four-handed technique, when resources allow.
5. Seal teeth of children even if cannot follow up.
6. Evaluate sealant retention within one year.

CDC on Fluoride[40]

1. Continue and extend community water fluoridation.
2. Decisions to initiate or continue a school fluoridation programs should be based on as assessment caries risk in this population and other fluoride alternatives.
3. Counsel parents regarding use of fluoride toothpastes by young children especially < 2 years to:
    a. Limit brushing to ≤ 2 times a day.
    b. Pea-sized amount.
    c. Supervised brushing.
    d. Spit out excess toothpaste.
4. Target Mouth rinsing to persons at high risk.
5. Prescribe fluoride supplements for children at high risk whose primary drinking water has low fluoride concentration – prescription dosage should be consistent with ADA, AAPD, and AAP.
6. Use fluoride gels, foams, or varnishes to at high-risk persons.

ASTDD on Sealants[41]

ASTDD cites the CDC sealant's recommendations.

ASTDD on Fluoride[42]

1. The Association of State and Territorial Dental Directors (ASTDD) fully supports and endorses community water fluoridation in all public water systems throughout the United States.
2. The Association of State and Territorial Dental Directors (ASTDD) supports the use of fluoride varnish, beginning with tooth eruption, for individuals at moderate to high risk for tooth decay as an effective adjunct in programs designed to reduce lifetime dental caries experience.
3. ASTDD supports the use of fluoride mouth rinse programs in schools for children age six years and older, when exposure to optimal systemic and topical fluorides is low, populations of children are at high risk for tooth decay and there is demonstrated support by school personnel.
4. ASTDD supports the use of fluoride supplements for children who are at high-risk for dental caries, whose primary source of drinking water has suboptimal levels of fluoride and whose other ingested sources of fluoride are low. Fluoride supplements should be prescribed based on caries risk assessment and fluoride history. Healthcare professionals should monitor parents' compliance with the current supplement dosage schedule on an ongoing basis.

The Task Force[124]

According to Community Guide rules of evidence, strong evidence shows that Community Water Fluoridation is effective in reducing the cumulative experience of dental caries within communities.

According to Community Guide rules of evidence, strong evidence shows that school-based and school-linked sealant delivery programs are effective in reducing decay in pits and fissures of children's teeth.

AAPHD

The American Association of Public Health Dentistry strongly supports innovative demonstration programs aimed at improving access to preventive and therapeutic oral health services for underserved populations and commits to working with the communities of interest to assure an independent and formal evaluation and dissemination of accurate information to the public and the profession about such model programs.[125]

The American Association of Public Health Dentistry strongly supports and encourages the use of pit and fissure sealants as well as fluorides in private dental practices and public dental health programs.[126]

The Association supports the inclusion of pit and fissure sealants as a covered preventive service by public and private third party payment programs.[126]

The Association urges health agency directors and practitioners to increase the public's awareness of this dental caries preventive measure.[126]

The American Association of Public Health Dentistry support changes in state dental practice acts that would allow the placement of dental sealants by dental hygienists in public health and institutional settings under the general supervision of dentists.[127]

Fluoride varnish is applied 2-4 times a year to those deemed at moderate or high caries risk in various public health settings by appropriately trained health professionals; Persons administering the topical fluoride treatment undergo the necessary training to apply the varnish properly to patients and are working within the scope of practice allowed in their jurisdiction; Parents and caregivers be advised that topical fluoride varnish in young children is not a substitute for community water fluoridation programs, dietary fluoride supplements, or dental care but a complement (i.e., every child should have a dental home by age one for the beginning of comprehensive infant oral care); and Federal and state government and foundations provide financial support and incentives for fluoride varnish research in different populations and delivery settings (i.e. children, adults and elderly, including those with special health care needs, and different public health settings) to better understand efficacy, effectiveness, applicability, program adoption, reach, and cost-effectiveness compared to other topical fluoride and caries preventive regimens.[43]

Appendix B

Tooth- age-specific probabilities of decay for the ForsythKids arm and the standard dental care arm.

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
	6	0.03836225	6	0.0147115
	7	0.04019419	7	0.0190559
	8	0.04210979	8	0.0251614
	9	0.04411248	9	0.0296159
	10	0.04620582	10	0.0342467
	11	0.04839348	11	0.04038
	12	0.0506792	12	0.0483715
	13	0.05306687	13	0.041243458
	14	0.05556044	14	0.043181455
	15	0.05816399	15	0.045204929
3	16	0.06088167	16	0.047317104
	17	0.06371775	17	0.049521299
	18	0.06667655	18	0.051820872
	19	0.06976252	19	0.054219282
	20	0.07298014	20	0.056720009
	21	0.076334	21	0.059326622
	22	0.07982871	22	0.062042703
	23	0.08346895	23	0.06487189
	24	0.08725946	24	0.067817866
	25	0.09120496	25	0.0708843
	26	0.09531023	26	0.074074907

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
	6	0.03560909	6	0.0133474
	7	0.03785862	7	0.0159392
	8	0.04024433	8	0.0196564
	9	0.0427737	9	0.0219132
	10	0.0454545	10	0.0243266
14	11	0.04829485	11	0.0271633
	12	0.05130315	12	0.0309694
	13	0.0544881	13	0.042348035
	14	0.05785872	14	0.044967674
	15	0.0614243	15	0.047738835
	16	0.06519441	16	0.050668956

	17	0.06917886	17	0.053765662
	18	0.07338771	18	0.057036772
	19	0.07783122	19	0.060490258
	20	0.08251981	20	0.06413422
	21	0.08746406	21	0.067976881
	22	0.09267463	22	0.072026525
	23	0.09816222	23	0.076291468
	24	0.10393752	24	0.080780019
	25	0.11001116	25	0.085500439
	26	0.11639362	26	0.090460873

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
	6	0.06250226	6	0.0224707
	7	0.06574681	7	0.0290419
	8	0.06914735	8	0.0379043
	9	0.07271008	9	0.0441587
	10	0.07644131	10	0.0505385
	11	0.08034742	11	0.058783
	12	0.08443488	12	0.0679349
	13	0.08871022	13	0.068945394
	14	0.09318002	14	0.072419313
	15	0.09785084	15	0.076049464
19	16	0.10272928	16	0.079840977
	17	0.10782186	17	0.08379892
	18	0.11313507	18	0.087928335
	19	0.11867528	19	0.092234174
	20	0.12444871	20	0.096721272
	21	0.13046144	21	0.101394353
	22	0.13671932	22	0.106257964
	23	0.14322792	23	0.111316434
	24	0.14999253	24	0.116573874
	25	0.15701808	25	0.122034117
	26	0.1643091	26	0.127700682

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
	6	0.07821965	6	0.0293268
	7	0.07996851	7	0.0356819
30	8	0.081753	8	0.044209
	9	0.0835737	9	0.0486396
	10	0.08543117	10	0.0527229

	11	0.08732598	11	0.0578862
	12	0.08925873	12	0.064812
	13	0.09122997	13	0.070903738
	14	0.09324029	14	0.072466154
	15	0.09529027	15	0.074059394
	16	0.09738047	16	0.075683893
	17	0.09951148	17	0.07734011
	18	0.10168388	18	0.079028495
	19	0.10389822	19	0.080749475
	20	0.10615508	20	0.082503502
	21	0.10845504	21	0.084291026
	22	0.11079866	22	0.086112482
	23	0.11318648	23	0.087968291
	24	0.11561907	24	0.089858894
	25	0.11809698	25	0.091784721
	26	0.12062076	26	0.093746197

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0	10	0
	11	0.0414364	11	0.018326
	12	0.04480562	12	0.0221541
	13	0.04734844	13	0.036799107
	14	0.05002801	14	0.038881663
	15	0.05285082	15	0.041075545
2	16	0.05582355	16	0.043385944
	17	0.05895307	17	0.0458182
	18	0.06224647	18	0.048377824
	19	0.06571101	19	0.051070457
	20	0.06935412	20	0.053901874
	21	0.07318339	21	0.056877975
	22	0.07720654	22	0.060004758
	23	0.08143143	23	0.063288334
	24	0.085866	24	0.066734872
	25	0.09051826	25	0.070350599
	26	0.09539629	26	0.074141793

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
	Age	Pr(decay)	Age	Pr(decay)
	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0.00849197	10	0.006065959
	11	0.00962168	11	0.0079913
	12	0.01028448	12	0.0084675
	13	0.01099242	13	0.008543285
	14	0.01174852	14	0.009130925
	15	0.01255596	15	0.009758465
4	16	0.01341814	16	0.01042855
	17	0.01433867	17	0.011143984
	18	0.01532137	18	0.011907736
	19	0.0163703	19	0.012722962
	20	0.01748976	20	0.013593004
	21	0.01868433	21	0.014521421
	22	0.01995882	22	0.015511952
	23	0.02131837	23	0.016568592
	24	0.02276837	24	0.017695529
	25	0.02431454	25	0.018897209
	26	0.02596293	26	0.020178334

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0.009786422	10	0.0039929
	11	0.01059088	11	0.0045688
	12	0.01157269	12	0.0054739
5	13	0.01264435	13	0.009827162
	14	0.01381387	14	0.01073611
	15	0.0150899	15	0.011727838
	16	0.01648184	16	0.012809651
	17	0.01799983	17	0.013989429
	18	0.01965483	18	0.015275692
	19	0.02145867	19	0.016677633
	20	0.02342412	20	0.018205176

	21	0.02556487	21	0.019868962
	22	0.02789568	22	0.021680463
	23	0.03043236	23	0.023651965
	24	0.03319184	24	0.025796627
	25	0.0361922	25	0.028128501
	26	0.0394527	26	0.030662554

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
12	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0.011708225	10	0.00436739
	11	0.01215009	11	0.0055926
	12	0.01305819	12	0.0062303
	13	0.0140332	13	0.010906573
	14	0.01507991	14	0.011720074
	15	0.01620339	15	0.01259324
	16	0.01740911	16	0.013530323
	17	0.01870283	17	0.0145358
	18	0.02009073	18	0.015614472
	19	0.02157936	19	0.016771433
	20	0.02317568	20	0.018012089
	21	0.02488708	21	0.019342185
	22	0.0267214	22	0.020767815
	23	0.02868695	23	0.022295436
	24	0.0307925	24	0.023931865
	25	0.03304734	25	0.025684322
	26	0.03546125	26	0.027560408

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
13	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0.0037634	10	0.0070913
	11	0.00435364	11	0.0080615
	12	0.00495886	12	0.0152028
	13	0.00564775	13	0.013836988
	14	0.00643172	14	0.015757714

	15	0.00732371	15	0.01794309
	16	0.00833837	16	0.020429007
	17	0.00949226	17	0.023256037
	18	0.01080409	18	0.026470021
	19	0.01229496	19	0.030122652
	20	0.01398865	20	0.034272193
	21	0.0159119	21	0.038984155
	22	0.01809471	22	0.04433204
	23	0.02057071	23	0.05039824
	24	0.02337744	24	0.057274728
	25	0.02655675	25	0.065064038
	26	0.0301551	26	0.073879995

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
15	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0	10	0
	11	0.0324192	11	0.0193432
	12	0.03885318	12	0.0221695
	13	0.04166082	13	0.0323787
	14	0.04466191	14	0.034711141
	15	0.04786839	15	0.037203211
	16	0.05129272	16	0.039864593
	17	0.05494788	17	0.042705375
	18	0.05884735	18	0.045736035
	19	0.0630051	19	0.048967429
	20	0.06743556	20	0.052410773
	21	0.07215358	21	0.056077608
	22	0.07717437	22	0.059979756
	23	0.08251346	23	0.064129285
	24	0.08818662	24	0.068538453
	25	0.09420979	25	0.073219648
	26	0.10059895	26	0.078185289

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
18	6	0	6	0
	7	0	7	0
	8	0	8	0

	9	0	9	0
	10	0	10	0
	11	0.0718322	11	0.0209321
	12	0.07892174	12	0.0273454
	13	0.08103068	13	0.062976872
	14	0.08319088	14	0.064655774
	15	0.08540332	15	0.066375278
	16	0.08766896	16	0.068136129
	17	0.0899888	17	0.069939103
	18	0.09236381	18	0.071784956
	19	0.09479497	19	0.073674448
	20	0.09728327	20	0.07560835
	21	0.09982968	21	0.077587414
	22	0.10243518	22	0.079612403
	23	0.10510074	23	0.081684071
	24	0.10782733	24	0.083803171
	25	0.11061591	25	0.085970449
	26	0.11346744	26	0.088186652

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
20	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0	10	0
	11	0.00743104	11	0.0040313
	12	0.00835598	12	0.0045566
	13	0.00939495	13	0.007301735
	14	0.01056173	14	0.008208554
	15	0.01187168	15	0.009226644
	16	0.0133419	16	0.010369296
	17	0.01499145	17	0.011651323
	18	0.01684145	18	0.013089139
	19	0.01891537	19	0.014700985
	20	0.02123916	20	0.01650703
	21	0.0238415	21	0.018529563
	22	0.02675397	22	0.020793128
	23	0.03001129	23	0.023324711
	24	0.03365148	24	0.026153858
	25	0.03771604	25	0.029312826
	26	0.04225006	26	0.032836656

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
21	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0.0040232	10	0.0008231
	11	0.00479815	11	0.0012285
	12	0.00541162	12	0.0018715
	13	0.00610304	13	0.00474327
	14	0.0068822	14	0.005348831
	15	0.00776005	15	0.006031094
	16	0.00874889	16	0.006799619
	17	0.00986248	17	0.007665098
	18	0.01111622	18	0.008639502
	19	0.01252733	19	0.009736214
	20	0.01411501	20	0.010970156
	21	0.01590066	21	0.012357959
	22	0.01790811	22	0.013918145
	23	0.0201638	23	0.015671262
	24	0.02269706	24	0.017640107
	25	0.02554028	25	0.019849851
	26	0.02872919	26	0.022328265

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
28	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0.0030213	10	0.0032893
	11	0.00354152	11	0.0037929
	12	0.00397812	12	0.0043414
	13	0.004468	13	0.00482544
	14	0.00501859	14	0.005420077
	15	0.00563625	15	0.00608715
	16	0.00632946	16	0.006835817
	17	0.00710731	17	0.007675895
	18	0.00797998	18	0.008618378
	19	0.00895885	19	0.009675558
	20	0.01005656	20	0.010861085
	21	0.01128725	21	0.01219023

	22	0.01266662	22	0.01367995
	23	0.01421213	23	0.0153491
	24	0.01594317	24	0.017218624
	25	0.01788122	25	0.019311718
	26	0.02005007	26	0.021654076

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
29	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0	10	0
	11	0.00839053	11	0.0025804
	12	0.0089892	12	0.003824
	13	0.00963016	13	0.00748454
	14	0.01031636	14	0.008017853
	15	0.0110509	15	0.008588736
	16	0.01183712	16	0.009199784
	17	0.01267856	17	0.00985375
	18	0.01357899	18	0.010553562
	19	0.01454243	19	0.011302346
	20	0.01557314	20	0.012103411
	21	0.01667568	21	0.012960303
	22	0.01785485	22	0.013876751
	23	0.01911578	23	0.014856743
	24	0.0204639	24	0.015904499
	25	0.02190498	25	0.017024504
	26	0.02344511	26	0.018221489

Tooth number	Standard care		ForsythKids	
	Age	Pr (decay)	Age	Pr (decay)
31	6	0	6	0
	7	0	7	0
	8	0	8	0
	9	0	9	0
	10	0	10	0
	11	0.0834452	11	0.0183422
	12	0.08667158	12	0.0214711
	13	0.08877233	13	0.068993665
	14	0.09091892	14	0.070661991
	15	0.09311212	15	0.072366541

16	0.09535267	16	0.074107892
17	0.09764133	17	0.075886633
18	0.09997886	18	0.077703357
19	0.10236599	19	0.079558629
20	0.1048035	20	0.081453057
21	0.10729209	21	0.083387183
22	0.10983253	22	0.085361608
23	0.11242555	23	0.087376898
24	0.11507188	24	0.08943362
25	0.11777223	25	0.091532326
26	0.12052731	26	0.093673568