Fluoride Use in Health Care Settings: Association with Children's Caries Risk

Advances in Dental Research
2018, Vol. 29(1) 24–34
© International & American Associations
for Dental Research 2018
Reprints and permissions:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/0022034517735297
journals.sagepub.com/home/adr

M. Fontana¹, G.J. Eckert², M.A. Keels³, R. Jackson², B. Katz²,
B.T. Levy⁴, and S.M. Levy⁴

Abstract

Expanded partnership with the medical community is an important strategy for reducing dental caries disparities. The purpose of this study was to assess the relationship between fluoride (F) “in office” (drops/tablets and/or varnish), as prescribed or applied by a health care professional by age 1 y, and 1) caries development and 2) presence of other caries risk factors or mediators (e.g., socioeconomic status). Child–primary caregiver (PCG) pairs ($N = 1,325$) were recruited in Indiana, Iowa, and North Carolina as part of a longitudinal cohort study to validate a caries risk tool for primary health care settings. PCGs completed a caries risk questionnaire, while children received caries examinations per the criteria of the International Caries Detection and Assessment System at ages 1, 2.5, and 4 y. Baseline responses regarding children's history of F in office were tested for association with other caries risk variables and caries experience at ages 2.5 and 4 y via generalized estimating equation models applied to logistic regression. The sample was 48% female, and many children (61%) were Medicaid enrolled. The prevalence of cavitated caries lesions increased from 7% at age 2.5 y to 25% by age 4 y. Children who received F in office were likely deemed at higher caries risk and indeed were significantly ($P < 0.01$) more likely to develop cavitated caries lesions by ages 2.5 and 4 y, even after F application (odds ratios: 3.5 and 2.3, respectively). Factors significantly associated with receiving F included the following: child being Medicaid enrolled, not having an employed adult in the household, child and PCG often consuming sugary drinks and snacks, and PCG having recent caries experience. Increased F in office from a health care provider by age 1 y was associated with known caries risk factors. Most (69%) children had never been to the dentist, suggesting that risk factors could be alerting medical providers and/or parents, thereby affecting in-office F recommendations. Differences among states could also be related to state-specific F-varnish reimbursement policies (ClinicalTrials.gov NCT01707797).

Keywords: dental caries, fluoride varnish, fluoride supplements, fluoride drops or tablets, interprofessional, pediatrician

Introduction

Dental caries is one of the most prevalent chronic diseases among children in the United States and the world (Kassebaum et al. 2015) and one of the most common unmet health care needs of economically disadvantaged children. Untreated cavities result in pain, loss of tooth structure, and infection of peridental tissues, with lasting effects on function, growth, development, and quality of life. According to the most recent National Health and Nutrition Examination Survey, disparities in US children's dental caries experience continue to persist (Dye et al. 2015). There also are clear issues related to access to care for young children; in some areas, as few as 25% of children saw a dentist in the previous year (US Department of Health and Human Services 2012).

Although numerous caries-preventive therapies are available today, fluoride (F)-based strategies have the strongest and most consistent level of evidence supporting their use to manage dental caries in children and adults (Centers for Disease Control and Prevention 2001; Marinho et al. 2003). Fluoridated community drinking water and F toothpaste are the most common sources of F in the United States and are largely responsible for the decreased caries prevalence across all age groups

in the United States in the last 50 y, which is why it is recommended that everyone be exposed to these sources of F as soon as teeth erupt in the oral cavity (Carey 2014; Iheozor-Ejiofor et al. 2015). People at increased risk for dental caries generally require more frequent or more concentrated exposure to F and could benefit from use of other F modalities, including, for example, prescribed supplements and professionally applied varnish.

Many children, especially lower socioeconomic status and minority children, have greater access to medical care than to dental care through the multiple well-child visits in the toddler years of life. Therefore, medical health care providers have been called on to assess the oral health of their patients; provide anticipatory guidance and counseling about oral hygiene,

¹University of Michigan, Ann Arbor, MI, USA

²Indiana University, Indianapolis, IN, USA

³Duke University, Durham, NC, USA

⁴University of Iowa, Iowa City, IA, USA

Corresponding Author:

M. Fontana, University of Michigan, 1011 North University, Room 2393,
Ann Arbor, MI 48109, USA.
Email: mfontan@umich.edu

F exposures, and diet; assist with referrals; and apply F varnish (FV; American Academy of Pediatrics, 2008, 2014). The purpose of this study was to assess the relationship between F provided by health care providers (i.e., prescribed supplements such as drops/tablets for home use and/or varnishes to be applied in the health care setting; referred to as F “in office” in this study) during the first year of a child’s life and 1) presence of other caries risk variables and 2) future caries development at ages 2.5 and 4 y. Use of F toothpaste at home, although extremely important for caries management, was not included as part of the in-office delivered strategies, as its use could be influenced not only by the recommendations of a health care professional but by other sources and experiences.

Methods

This study was part of a 3-y multisite prospective study aimed at developing and validating a caries risk tool for medical health care settings. Child–primary caregiver (PCG) pairs ($N = 1,325$), stratified by Medicaid status and representing diverse racial/ethnic groups, were recruited primarily through 3 medical research networks: the Pediatric Research Network in Indianapolis, Indiana (IN); the Iowa Research Network in Iowa City, Iowa (IA); and Duke University’s Primary Care Research Consortium in Durham, North Carolina (NC). The University of Michigan (Ann Arbor, Michigan) managed and coordinated the project. Institutional Review Board approval was obtained at all 4 institutions. This report conforms to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cohort studies.

Each child was paired with his or her PCG. “PCG” was defined as the individual consistently responsible for the child’s housing, health, and safety and, for consenting purposes, was limited to those PCGs who were also the parent or legal guardian. Inclusion criteria included the PCG being at least 18 y old or an emancipated minor, the child being 12 ± 3 mo old and generally healthy, provision of written informed consent by the PCG and for participation of the child, completion of the risk questionnaire by the PCG and a dental examination by the child, and availability for 2 follow-up study visits and multiple intermediate contacts between examination visits. Exclusion criteria included children who were in foster care, needed antibiotic and/or sedative premedication prior to a dental examination, had uncontrolled epilepsy, had active cancer treatment, or had an unrepaired congenital heart defect. Also, PCGs were excluded if they could not read or speak in English or Spanish.

For this study, PCGs completed a self-administered 52-item caries risk questionnaire at baseline (child, $1 \text{ y} \pm 3 \text{ mo}$ of age). The questionnaire was developed from a conceptual framework that considered dental caries a chronic disease process, with determinants both social (e.g., socioeconomic status) and biological (e.g., bacteria, diet, environment/oral hygiene), including risk indicators (e.g., caries experience), risk factors (e.g., dietary behaviors), protective factors (e.g., preventive treatments received), and social mediators associated with the child and the PCG (Fontana 2015). Sections of the questionnaire

associated with caries experience and oral hygiene of teeth (including F in office: prescription of F supplements and/or application of varnish in health care settings) were completed only if the child had teeth (1,227 of the 1,325 enrolled child-PCG pairs). The questionnaire included the following 2 questions about F in office:

- “Did your child’s doctor or dentist prescribe fluoride drops or tablets?”
- “Did your child receive fluoride painted/put on their teeth from a health professional (doctor, dentist, nurse, hygienist, etc.)?”

Children received a dental examination, based on the criteria of the International Caries Detection and Assessment System (ICDAS; 2017), by trained and calibrated dentists or hygienists at baseline, 18 mo after baseline (child, $2.5 \text{ y} \pm 3 \text{ mo}$ of age), and 36 mo after baseline (child, $4 \text{ y} \pm 3 \text{ mo}$ of age). Teeth were cleaned with a toothbrush, air or gauze dried, and assessed under light (Orascope Endeavour headlamps) without magnification. No dental radiographs were obtained. PCGs were informed of any conditions requiring treatment.

Baseline responses regarding children’s history of F prescribed or applied by a health care provider were tested for association with each of the other baseline questionnaire items via logistic regression with F prescribed or applied as the outcome. Baseline F prescribed or applied was then tested for association with the child’s caries experience at ages 2.5 and 4 y (separately) via logistic regression with presence of caries as the outcome (defined as a cavitated lesion: ICDAS ≥ 3 or filling) and with receipt of FV and/or drops/tablets as the independent variable. As the number of children receiving F drops/tablets was small, the analyses were focused on children who received FV or either FV or F drops/tablets. Analyses combining the 3 study sites used a generalized estimating equation model including study site as a cluster effect. Because of different reimbursement policies for FV in each state (IN, IA, NC), analyses of questionnaire responses were also performed by study site.

Results

This study sample was 48% female, 13% Hispanic, 38% non-Hispanic white, 36% non-Hispanic black, and 13% other or multiracial; 61% was enrolled in Medicaid; and 95% resided in urban communities (Table 1). Twenty-six percent of children at NC, 14% at IA, and 2% at IN had received F in office by age 1 y. Of the children who had received F in office, most (93%) received FV, and only 9% received drops/tablets (Table 2).

Sixty-nine percent of children receiving F had never been to the dentist, suggesting that a different health care professional had prescribed or applied the F treatment. At 2.5 y of age, 7% of the children had cavitated caries lesions. Prevalence was 7% for girls versus 6% for boys; 2%, 8%, 13%, and 6% ($P = .03$) for non-Hispanic whites, Hispanics, non-Hispanic blacks, and non-Hispanic multiple/other, respectively; 10% for Medicaid

Table 1. Demographics of Children Who Had at Least 1 Tooth Erupted at Baseline (Age, 1 y).

	All Sites (n = 1,227)	North Carolina (n = 409)	Indiana (n = 489)	Iowa (n = 329)
Child race/ethnicity				
White non-Hispanic	38	39	20	62
Black non-Hispanic	36	37	51	13
Hispanic	13	10	18	11
Multirace	11	12	10	12
Other non-Hispanic	2	2	1	3
Medicaid				
Yes	61	52	78	46
No	39	48	21	54
Missing	<1	—	<1	—
Urban-rural status				
Rural	5	3	1	14
Urban	95	97	99	86
Primary caregiver relation to child				
Mother	94	92	96	92
Father	6	8	4	6
Grandmother	<1	—	—	1
Legal guardian	<1	<1	—	—
Child sex				
Female	48	48	48	48
Male	52	52	52	52
Age				
Primary caregiver, y	29 (6)	30 (6)	27 (6)	30 (6)
Child, mo	12 (2)	12 (2)	11 (2)	12 (2)

Values are presented as percentage or mean (SD).

Table 2. Children Who Received Fluoride “In Office” (Drops/Tablets or Varnish) by Age 1 y.

Fluoride	All Sites	North Carolina	Indiana	Iowa
Drops/tablets				
No	1212 (99)	401 (98)	483 (99)	328 (100)
Yes	15 (1)	8 (2)	6 (1)	1 (<1)
Varnish				
No	1077 (88)	307 (75)	485 (99)	285 (87)
Yes	150 (12)	102 (25)	4 (1)	44 (13)
Drops/tablets or varnish				
No	1066 (87)	303 (74)	479 (98)	284 (86)
Yes	161 (13)	106 (26)	10 (2)	45 (14)

Values are presented as n (%).

enrolled versus 1% not ($P = .02$); and 10% for rural versus 6% for nonrural ($P = .02$). Twenty-five percent of children had cavitated caries experience at age 4 y. Prevalence was 22% for girls versus 27% for boys ($P = .01$); 11%, 35%, 37%, and 55% ($P < .01$) for non-Hispanic whites, Hispanics, non-Hispanic blacks, and non-Hispanic multiple/other, respectively; 33% for Medicaid enrolled versus 12% versus not ($P < .01$); and 17% for rural versus 25% for nonrural ($P = .36$).

Children who received F in office were likely deemed at higher caries risk and indeed were significantly ($P < .01$) more likely to develop cavitated caries lesions by ages 2.5 and 4 y, even after F application (odds ratios: 3.5 and 2.3, respectively; Table 3). The following factors were significantly ($P < .05$) associated with receipt of F in office (Tables 4 and 5) in at least 2 of the 3 sites, mostly NC and IA, because of the very low numbers of children who received F in IN, so IN results need to be interpreted with caution:

Factors related to socioeconomic status: Medicaid enrollment ($P < .01$, NC and IA), child not being covered by additional health insurance ($P < .01$, NC and IA), child not being covered by additional dental insurance ($P < .01$, NC and IA), child participating in other public assistance programs ($P < .01$, NC and IA), and no adult in the household employed ($P < .01$, NC; $P = .01$, IA)

Factors related to cariogenic behaviors by the child: higher frequency of sugary drink consumption ($P < .01$, NC; $P = .01$, IA) and higher frequency of sugary snack consumption ($P = .01$, NC; $P < .01$, IN)

Factors associated with a higher caries risk of the PCG: PCG having had cavities, fillings, and/or teeth pulled in the last 2 y ($P < .01$, NC; $P = .02$, IN); higher frequency of sugary snack consumption ($P = .02$, NC; $P = .02$, IA); and higher frequency of sugary drink consumption ($P < .01$, NC; $P < .01$, IN)

Table 3. Relationships between Development of Caries and Fluoride “In Office” (Drops/Tablets and/or Varnish) Prescribed/Applied by a Health Care Professional.

Age: Received Fluoride	All		North Carolina		Indiana		Iowa	
	Caries	P Value	Caries	P Value	Caries	P Value	Caries	P Value
2.5 y								
Drop/tablet								
No	64 (7)		23 (7)		34 (10)		7 (2)	
Yes	5 (38)		0 (0)		5 (100)		0 (0)	
Varnish								
No	55 (6)	<0.01	14 (5)	0.06	37 (11)	0.04	4 (2)	0.03
Yes	14 (12)		9 (12)		2 (50)		3 (8)	
OR (95% CI)	2.58 (2.03 to 3.28)		2.30 (0.95 to 5.54)		8.49 (1.16 to 62.04)		5.45 (1.17 to 25.40)	
Both								
No	50 (6)	0.01	14 (6)	0.08	32 (9)	<0.01	4 (2)	0.03
Yes	19 (15)		9 (11)		7 (78)		3 (8)	
OR (95% CI)	3.54 (1.86 to 6.73)		2.17 (0.90 to 5.23)		34.34 (6.84 to 172.33)		5.27 (1.13 to 24.55)	
4 y								
Drop/tablet								
No	221 (25)		76 (25)		116 (34)		29 (11)	
Yes	6 (55)		2 (33)		4 (100)		0 (0)	
Varnish								
No	190 (24)	<0.01	51 (22)	0.01	118 (35)	0.52	21 (9)	0.02
Yes	37 (35)		27 (39)		2 (50)		8 (24)	
OR (95% CI)	2.22 (1.93 to 2.56)		2.27 (1.28 to 4.02)		1.90 (0.26 to 13.65)		3.11 (1.25 to 7.75)	
Both								
No	186 (23)	<0.01	51 (22)	0.01	114 (34)	0.03	21 (9)	0.02
Yes	41 (36)		27 (38)		6 (75)		8 (24)	
OR (95% CI)	2.33 (2.07 to 2.63)		2.14 (1.21 to 3.78)		5.89 (1.17 to 29.67)		2.97 (1.20 to 7.40)	

Values are presented as *n* (%) unless noted otherwise. Blank *P* value cells indicate that sample numbers were too small to calculate significance. 95% CI, 95% confidence interval; OR, odds ratio.

Child's visits to dentist: child being taken frequently to the dentist ($P = .04$, NC; $P < .01$, IA)

In addition, other risk factors, presented next, were associated with the child receiving F in office at a single site (Tables 4 and 5). Because of the limited number of children receiving F at the IN site, the IN results need to be interpreted with caution:

Factors associated with the PCG: PCG being the mother ($P = .02$, NC), PCG being female ($P = .02$, NC), higher frequency of PCG's gums bleeding ($P < .01$, NC), higher frequency of PCG drinking anything other than water before bedtime ($P < .01$, NC), higher frequency of PCG seeing a health care provider for regular checkups ($P < .01$, IN), lower frequency of PCG getting dental checkups ($P < .01$, NC), PCG not having health insurance ($P < .01$, NC), PCG not having dental insurance ($P < .01$, NC), PCG stating that she or he does an excellent job at taking care of the child's teeth ($P < .01$, NC), PCG taking worse care of the child's medical health ($P < .01$, IA), and PCG reporting a lower house income ($P < .01$, NC)

Factors associated with the child: higher frequency of PCG checking the child's teeth ($P < .01$, NC) and higher frequency of child going to sleep while nursing ($P < .05$, NC)

The following clinical variables were also associated with receiving F by a health care provider: child having spacing of

anterior lower incisors ($P = .04$, NC), not having a thick maxillary labial frenum ($P < .01$, IN), and having noncavitated or white spot lesions (ICDAS 1 and 2; $P = .03$, IN).

Discussion

When fluoridated water is not available, prescription of dietary F supplements (e.g., drops or tablets) by a health care provider can be considered for children at high risk for dental caries (Rozier et al. 2010), because their use has been associated with a reduction in caries incidence, primarily in permanent teeth, although the evidence is not as compelling for deciduous teeth (Tubert-Jeannin et al. 2011). However, to avoid development of dental fluorosis, testing the water is important prior to prescribing supplements. However, FV is becoming the standard for F applications in health care settings because of its ease of application, safety, and significant body of clinical evidence (Marinho et al. 2013), suggesting a substantial caries-inhibiting effect in permanent and primary teeth (caries-preventive fractions of 43% and 37%, respectively).

In support of the suggested preference for recommendation of FV, our data show that the majority (93%) of children by age 1 who received F in office received FV, with only 9% receiving drops/tablets. Yet, only 26% of children with teeth at age 1 y in our study had received F in office from a health care provider. The US Preventive Services Task Force's published guidelines recommend that physicians regularly apply FV on the primary

Table 4. Associations of Baseline Risk Questionnaire Responses (Child Related) with F “In Office” (Drops/Tablets or Varnish).

	All	North Carolina		Indiana		Iowa	
	n (%)	n (%)	P Value	n (%)	P Value	n (%)	P Value
Child race/ethnicity							
White	37 (8)	13 (8)		2 (2)		22 (11)	
Black	80 (18)	69 (45)		4 (2)		7 (17)	
Hispanic	18 (11)	11 (28)	<0.01	3 (3)	0.81	4 (11)	0.09
Multiracial/other	26 (17)	13 (22)		1 (2)		12 (24)	
Medicaid							
No	16 (3)	6 (3)	<0.01	1 (1)	0.38	9 (5)	<0.01
Yes	145 (19)	100 (47)		9 (2)		36 (24)	
Urban-rural status							
Rural	5 (8)	2 (14)	0.32	0 (0)	0.99	3 (7)	0.15
Urban	156 (13)	104 (26)		10 (2)		42 (15)	
Child sex							
Female	77 (13)	50 (25)	0.77	5 (2)	0.89	22 (14)	0.87
Male	84 (13)	56 (27)		5 (2)		23 (13)	
Does your child have any cavities or fillings?							
No	158 (13)	105 (26)	0.97	9 (2)	0.04	44 (14)	0.96
Yes	3 (18)	1 (25)		1 (17)		1 (14)	
How often does an adult brush your child's teeth?							
Daily	109 (15)	67 (28)	0.61	9 (3)		33 (16)	0.16
Weekly	23 (12)	13 (21)		1 (1)		9 (14)	
Monthly	4 (17)	3 (25)		0 (0)		1 (17)	
Never	25 (8)	23 (23)		0 (0)		2 (4)	
How often are your child's teeth brushed with toothpaste?							
Daily	66 (16)	40 (30)	0.42	5 (3)	0.09	21 (18)	0.12
Weekly	21 (17)	9 (28)		3 (7)		9 (19)	
Monthly	2 (15)	2 (40)		0 (0)		0 (0)	
Never	72 (10)	55 (23)		2 (1)		15 (9)	
How often are your child's teeth brushed with nonfluoride toothpaste?							
Daily	42 (15)	27 (29)	0.42	6 (5)		9 (12)	0.09
Weekly	9 (10)	7 (29)		0 (0)		2 (7)	
Monthly	6 (43)	3 (50)		0 (0)		3 (50)	
Never	103 (12)	69 (24)		3 (1)		31 (14)	
How often does your child share a toothbrush with another person?							
Daily	1 (13)	0 (0)	0.99	0 (0)		1 (20)	0.93
Weekly	0 (0)	0 (0)		0 (0)		0 (0)	
Monthly	1 (17)	1 (25)		0 (0)		0 (0)	
Never	159 (13)	105 (26)		10 (2)		44 (14)	
When brushing, how often do your child's gums bleed?							
Daily	1 (7)	0 (0)	1.00	0 (0)	1.00	1 (14)	1.00
Weekly	0 (0)			0 (0)		0 (0)	
Monthly	0 (0)	0 (0)		0 (0)		0 (0)	
Never	160 (13)	106 (26)		10 (2)		44 (14)	
How often do you clean inside your child's mouth and/or gums?							
Daily	117 (16)	75 (31)	0.07	9 (3)		33 (17)	0.09
Weekly	21 (10)	12 (18)		1 (1)		8 (13)	
Monthly	6 (12)	4 (25)		0 (0)		2 (17)	
Never	17 (7)	15 (19)		0 (0)		2 (3)	
Does your child usually (throughout the day) drink from a bottle or sippy cup?							
No	14 (22)	10 (37)	0.18	0 (0)	0.99	4 (16)	0.73
Yes	147 (13)	96 (25)		10 (2)		41 (13)	

(continued)

Table 4. (continued)

	All	North Carolina		Indiana		Iowa	
	n (%)	n (%)	P Value	n (%)	P Value	n (%)	P Value
How often does your child go to sleep while nursing or while drinking?							
Daily	80 (14)	57 (31)	0.04	8 (3)	0.71	15 (13)	0.98
Weekly	21 (15)	16 (32)		0 (0)		5 (14)	
Monthly	3 (13)	3 (33)		0 (0)		0 (0)	
Never	57 (11)	30 (18)		2 (1)		25 (15)	
How often does your child eat or drink anything other than plain water before bed?							
Daily	94 (12)	68 (25)	0.72	6 (2)	0.96	20 (11)	0.41
Weekly	25 (16)	15 (31)		2 (3)		8 (20)	
Monthly	3 (12)	3 (38)		0 (0)		0 (0)	
Never	39 (14)	20 (24)		2 (2)		17 (17)	
How often does your child typically drink tap water?							
Daily	100 (14)	62 (25)	0.78	7 (3)	0.76	31 (14)	0.94
Weekly	20 (13)	15 (27)		1 (1)		4 (13)	
Monthly	4 (13)	4 (36)		0 (0)		0 (0)	
Never	37 (12)	25 (28)		2 (1)		10 (17)	
How often do you give your child sugary snacks?							
3×/d	7 (13)	6 (60)	0.01	1 (3)	<0.01	0 (0)	0.74
1× to 2×/d	70 (14)	46 (30)		5 (2)		19 (15)	
Weekly	48 (15)	29 (28)		3 (3)		16 (16)	
Monthly	7 (8)	4 (13)		1 (3)		2 (9)	
Never	28 (10)	20 (18)		0 (0)		8 (10)	
How often do you give your child sugary drinks?							
3×/d	9 (20)	5 (56)	<0.01	2 (6)	0.61	2 (50)	0.01
1× to 2×/d	48 (15)	35 (37)		4 (2)		9 (18)	
Weekly	41 (18)	27 (36)		1 (1)		13 (20)	
Monthly	7 (10)	1 (5)		0 (0)		6 (25)	
Never	55 (10)	37 (18)		3 (2)		15 (8)	
How often do you clean your child's pacifier with juice, soda, honey, sweet drink?							
Daily	2 (11)	1 (20)	0.86	1 (8)	0.48	0 (0)	0.64
Weekly	3 (13)	2 (22)		0 (0)		1 (33)	
Monthly	2 (14)	1 (50)		0 (0)		1 (33)	
Never	73 (11)	48 (24)		3 (1)		22 (12)	
Don't use pacifier	81 (15)	54 (28)		6 (3)		21 (15)	
How often do you clean your child's pacifier by putting it in your mouth?							
Daily	20 (12)	14 (29)	0.81	1 (1)	0.52	5 (21)	0.53
Weekly	5 (7)	4 (18)		0 (0)		1 (6)	
Monthly	4 (16)	2 (29)		0 (0)		2 (25)	
Never	49 (12)	32 (24)		1 (1)		16 (12)	
Don't use pacifier	83 (15)	54 (28)		8 (4)		21 (14)	
How often do you share/taste food with your child using the same utensils?							
Daily	82 (15)	55 (30)	0.15	7 (3)	0.70	20 (16)	0.45
Weekly	38 (14)	22 (22)		2 (2)		14 (16)	
Monthly	2 (4)	1 (6)		0 (0)		1 (6)	
Never	39 (12)	28 (26)		1 (1)		10 (10)	
How often do you kiss your child on the mouth?							
Daily	104 (14)	66 (28)	0.51	7 (2)		31 (17)	0.22
Weekly	15 (10)	11 (19)		0 (0)		4 (8)	
Monthly	4 (11)	3 (19)		0 (0)		1 (7)	
Never	38 (13)	26 (27)		3 (2)		9 (11)	
How often do you take your child to the dentist?							
Never	110 (11)	90 (24)	0.04	6 (1)		14 (6)	<0.01
Only when in pain	0 (0)	0 (0)		0 (0)		0 (0)	
Yearly	20 (25)	8 (53)		0 (0)		12 (29)	
Twice yearly	30 (29)	8 (42)		3 (8)		19 (40)	

(continued)

Table 4. (continued)

	All	North Carolina		Indiana		Iowa	
	<i>n</i> (%)	<i>n</i> (%)	<i>P</i> Value	<i>n</i> (%)	<i>P</i> Value	<i>n</i> (%)	<i>P</i> Value
Is it very difficult to get your child to the doctor or the dentist?							
No	152 (13)	102 (26)	0.43	8 (2)	0.02	42 (13)	0.10
Yes	9 (23)	4 (36)		2 (11)		3 (33)	
Is your child covered by additional health insurance?							
No	131 (20)	93 (47)	<0.01	7 (2)	0.90	31 (23)	0.01
Yes	30 (5)	13 (6)		3 (2)		14 (7)	
Is your child covered by additional dental insurance?							
No	134 (16)	92 (33)	<0.01	8 (2)	0.62	34 (19)	0.01
Yes	27 (7)	14 (11)		2 (2)		11 (7)	
Does your child participate in public assistance programs in addition to Medicaid?							
No	22 (4)	18 (8)	<0.01	1 (1)	0.32	3 (2)	<0.01
Yes	139 (19)	88 (45)		9 (2)		42 (27)	
Was your child born more than 3 weeks (premature) before the expected delivery date?							
No	137 (13)	87 (25)	0.15	8 (2)	0.61	42 (15)	0.20
Yes	24 (14)	19 (34)		2 (3)		3 (7)	
Was your child delivered by C-section?							
No	110 (13)	67 (26)	0.88	5 (2)	0.25	38 (16)	0.07
Yes	51 (13)	39 (25)		5 (3)		7 (8)	
Any d1mft ^a							
No	154 (14)	102 (28)		8 (2)	0.12	44 (14)	
Yes	2 (6)	0 (0)		2 (7)		0 (0)	
Any d2mft ^a							
No	154 (14)	102 (27)		8 (2)	0.03	44 (14)	
Yes	2 (11)	0 (0)		2 (12)		0 (0)	

Blank *P* value cells indicate that sample numbers were too small to calculate significance.

F, fluoride.

^aQuestion was assessed clinically.

teeth of all children from initial tooth eruption to age 5 y (Moyer 2014). The American Academy of Pediatrics (2008, 2014) also recommends that FV be regularly applied in the primary care setting every 3 to 6 mo starting at tooth emergence. Yet these recommendations contrast with some organizations, such as the American Dental Association, advocating that FV use be based on children's caries risk (Weyant et al. 2013).

It is likely that, to be cost-effective—given the large disparities in caries experience early in life, as shown in our study—preventive services and anticipatory guidance in the toddler years need to be targeted per the risk of the child (Fontana 2015; Milgrom and Cunha-Cruz 2017). However, the US Preventive Services Task Force's decision was based in part on the fact that, although several caries risk assessment tools exist, none have been validated for use among US children (Tellez et al. 2013) or for use in the primary care setting (Chou et al. 2013, 2014).

A 2014 study assessing pediatricians' oral health attitudes and practices concluded that most respondents supported providing oral health activities in medical offices, but fewer now (vs. 2008) reported engaging in these activities with all patients.

Significantly more respondents agreed that they should apply FV (19% in 2008 vs. 41% in 2012), but only 7% reported doing so with >75% of patients (Quiñonez et al. 2014). The findings from our study support these reports and show that the majority of children by age 1 y in the 3 study sites (IN, IA, and NC) had not received F in office. However, children in our study who did receive F in office were significantly ($P < .001$) more likely to develop cavitated caries lesions by ages 2.5 and 4 y. We hypothesized that receipt of F in office might be a consequence of a perceived increased caries risk and that risk factors or mediators could be alerting health care providers and/or parents, thus affecting the F recommendations.

Our data demonstrated that several of the caries risk questionnaire variables were associated with the receipt of these F modalities: factors related to low socioeconomic status (e.g., being Medicaid enrolled), etiologic factors related to cariogenic behaviors by the child (e.g., having frequent exposures to cariogenic drinks and snacks), and factors associated with a higher caries risk of the PCG (e.g., having had recent caries experience, having frequent exposure to cariogenic drinks and snacks). This relationship between positive caries-preventive

Table 5. Associations of Baseline Risk Questionnaire Responses (Primary Caregiver Related) with F “In Office” (Drops/Tablets or Varnish).

	All	North Carolina		Indiana		Iowa	
	n (%)	n (%)	P Value	n (%)	P Value	n (%)	P Value
Caregiver relation to child							
Mother	159 (14)	105 (28)	0.02	10 (2)		44 (14)	0.18
Not mother	2 (3)	1 (3)		0 (0)		1 (4)	
Caregiver sex							
Male	1 (1)	1 (3)	0.02	0 (0)	0.99	0 (0)	0.99
Female	160 (14)	105 (28)		10 (2)		45 (15)	
How often do you check your child's teeth for anything unusual?							
Daily	85 (16)	59 (35)	0.01	6 (2)	0.91	20 (17)	0.68
Weekly	56 (13)	34 (23)		2 (1)		20 (15)	
Monthly	5 (5)	5 (17)		0 (0)		0 (0)	
Never	15 (8)	8 (12)		2 (3)		5 (10)	
Do you have any natural teeth?							
No	3 (19)	0 (0)	0.99	2 (15)	0.01	1 (50)	0.19
Yes	158 (13)	106 (26)		8 (2)		44 (13)	
Have you had cavities, fillings and/or teeth pulled in the last 2 years?							
No	71 (13)	49 (25)	<0.01	2 (1)	0.02	20 (13)	0.40
Yes	87 (13)	57 (27)		6 (2)		24 (14)	
No teeth	3 (19)	0 (0)		2 (15)		1 (50)	
How often do your gums bleed when you brush?							
Daily	14 (12)	10 (32)	<0.01	0 (0)	0.11	4 (17)	0.29
Weekly	18 (11)	12 (31)		1 (1)		5 (14)	
Monthly	28 (10)	21 (20)		1 (1)		6 (7)	
Never	97 (15)	62 (26)		6 (3)		29 (15)	
No teeth	3 (19)	0 (0)		2 (15)		1 (50)	
How often do you brush your teeth?							
Daily	157 (13)	106 (26)		8 (2)	0.11	43 (13)	0.42
Weekly	1 (5)	0 (0)		0 (0)		1 (100)	
Monthly	0 (0)	0 (0)		0 (0)			
Never	0 (0)			0 (0)			
No teeth	3 (19)	0 (0)		2 (15)		1 (50)	
How often do you use toothpaste when you brush?							
Daily	156 (13)	106 (26)		8 (2)	0.11	42 (13)	0.62
Weekly	2 (17)	0 (0)		0 (0)		2 (100)	
Monthly	0 (0)	0 (0)		0 (0)		0 (0)	
Never	0 (0)			0 (0)			
No teeth	3 (19)	0 (0)		2 (15)		1 (50)	
How often do you eat sugary snacks?							
3×/d	31 (18)	19 (44)	0.02	4 (4)		8 (33)	0.02
1×-2×/d	69 (12)	47 (25)		4 (2)		18 (11)	
Weekly	39 (10)	25 (19)		2 (2)		12 (10)	
Monthly	16 (20)	10 (34)		0 (0)		6 (26)	
Never	5 (17)	4 (33)		0 (0)		1 (10)	
How often do you drink sugary drinks?							
3×/d	43 (16)	28 (34)	<0.01	6 (4)	<0.01	9 (23)	0.20
1× or 2×/d	67 (14)	47 (34)		2 (1)		18 (16)	
Weekly	28 (11)	20 (21)		2 (2)		6 (7)	
Monthly	11 (10)	5 (11)		0 (0)		6 (16)	
Never	11 (9)	5 (11)		0 (0)		6 (11)	
How often do you eat or drink anything other than plain water before bed?							
Daily	81 (17)	59 (40)	<0.01	6 (2)	0.93	16 (21)	0.17
Weekly	31 (15)	22 (31)		1 (1)		8 (15)	
Monthly	6 (8)	3 (14)		0 (0)		3 (16)	
Never	43 (9)	22 (13)		3 (3)		18 (10)	
How often do you see your health care provider for regular checkups?							
2×/y	57 (14)	39 (33)	0.07	5 (2)	<0.01	13 (17)	0.17
Yearly	81 (13)	54 (24)		4 (2)		23 (12)	

(continued)

Table 5. (continued)

	All	North Carolina		Indiana		Iowa	
	n (%)	n (%)	P Value	n (%)	P Value	n (%)	P Value
Every other year	8 (8)	4 (12)		1 (3)		3 (9)	
Never	15 (17)	9 (29)		0 (0)		6 (27)	
How often do you get dental checkups?							
2x/y	52 (10)	35 (19)	<0.01	2 (1)	0.73	15 (9)	0.06
Yearly	51 (15)	29 (28)		4 (3)		18 (23)	
Every other year	28 (13)	18 (27)		2 (2)		8 (14)	
Never	29 (19)	23 (46)		2 (3)		4 (13)	
Do you have health insurance?							
No	41 (20)	34 (44)	<0.01	1 (1)	0.43	6 (21)	0.22
Yes	119 (12)	71 (22)		9 (2)		39 (13)	
Do you have dental insurance?							
No	65 (18)	51 (35)	<0.01	3 (2)	0.93	11 (15)	0.66
Yes	95 (11)	54 (21)		7 (2)		34 (13)	
Do you primarily speak a language other than English at home?							
No	135 (14)	86 (26)	0.81	6 (2)	0.21	43 (16)	0.04
Yes	26 (11)	20 (27)		4 (4)		2 (4)	
Is an adult in the child's household employed?							
No	49 (24)	34 (59)	<0.01	5 (4)	0.06	10 (29)	0.01
Yes	112 (11)	72 (21)		5 (1)		35 (12)	
I do a/an ____ job taking care of the child's teeth and/or gums.							
Excellent	39 (15)	35 (39)	<0.01	0 (0)		4 (8)	0.06
Very good	58 (15)	31 (23)		5 (3)		22 (22)	
Good	51 (12)	31 (23)		5 (3)		15 (12)	
Fair	12 (9)	9 (22)		0 (0)		3 (6)	
Poor	1 (3)	0 (0)		0 (0)		1 (13)	
I do a/an ____ job taking care of the child's medical health.							
Excellent	111 (14)	78 (27)	0.72	6 (2)		27 (14)	<0.01
Very good	43 (13)	24 (23)		4 (4)		15 (13)	
Good	5 (7)	3 (19)		0 (0)		2 (10)	
Fair	2 (33)	1 (33)		0 (0)		1 (100)	
Which of the following categories best represents the combined income?							
<\$5,000	35 (19)	26 (62)	<0.01	3 (3)		6 (21)	0.06
\$5,000 to \$9,999	22 (23)	16 (46)		1 (2)		5 (36)	
\$10,000 to \$19,999	22 (21)	13 (52)		2 (4)		7 (27)	
\$20,000 to \$29,999	27 (19)	18 (50)		1 (2)		8 (21)	
\$30,000 to \$39,999	8 (11)	4 (17)		0 (0)		4 (17)	
\$40,000 to \$49,999	9 (12)	5 (21)		0 (0)		4 (15)	
\$50,000 to \$79,999	8 (5)	4 (8)		1 (2)		3 (5)	
\$80,000 to \$99,999	3 (3)	1 (3)		0 (0)		2 (5)	
≥\$100,000	3 (2)	3 (4)		0 (0)		0 (0)	
Don't know	24 (16)	16 (30)		2 (3)		6 (32)	

Blank P value cells indicate that sample numbers were too small to calculate significance.
F, fluoride.

behaviors and increased risk is not uncommon. For example, in a recent study in Singapore, although higher frequencies of dental visits and toothbrushing were associated with lower plaque accumulation, they were also associated with increased caries risk in young children, suggesting that these caries risk factors could be a consequence rather than the cause of caries (Un Lam et al. 2017).

Although evidence is weak for preventive care early in life that reduces dental caries experience (Beil et al. 2014; Bhaskar

et al. 2014), some data suggest that increased frequency of preventive care through medical settings can result in reduced caries experience (Kranz et al. 2015). In fact, limited data suggest that the setting/provider type does not influence the effectiveness of preventive services on children's caries experience (Kranz et al. 2014), but more work is needed to link medical and dental offices to ensure continuity of dental care and sufficient exposure to F based on caries risk. In our study, having frequent dental visits was associated with increased receipt of

FV, as expected if the dental provider determined the child to be at risk for caries; yet, the majority of children in this study had not visited a dentist by age 1. In contrast, a recent study based on insurance claims data in Alabama concluded that there was no evidence that preventive care before age 2 y reduces caries-related treatment visits regardless of provider, leading the authors to suggest that the current participation of primary care providers in caries prevention early in life has limited effects on caries-related treatments, while dentist-delivered care increases caries-related treatments and expenditures (Blackburn et al. 2017). However, as mentioned, it has been argued that to be cost-effective, preventive services need to be targeted to the caries risk of the child (Fontana 2015; Milgrom and Cunha-Cruz 2017). Thus, evidence-based tools to facilitate risk-based anticipatory guidance, screening, and FV application could be important to enhance risk-based adoption and efficacy of preventive strategies for children at risk.

In fact, findings of our study suggest that health care providers might already be recommending F in office based on the presence of caries risk factors, as these young children did not have significant caries lesion development by age 1 y. The association of the use of these F modalities with caries experience at ages 2.5 and 4 y could also suggest that the actual F exposure might be insufficient based on the child's caries risk level. Our study did not obtain data on the frequency of FV application; therefore, there could have been only 1 application, thereby limiting the beneficial effect of FV (Weintraub and Hysan 2003). Weintraub et al. (2006) demonstrated a dose-response effect of >1 FV application in combination with oral health counseling. In addition, the data that we obtained were self-reported from the PCG, which is a limitation to consider. Furthermore, it is plausible that there was poor compliance with children actually taking the F supplements or using toothpaste on a daily basis and hence limited benefit from these F sources, although this was not assessed in the current study. In a survey of >200 parents, Flood et al. (2017) found that adherence to dietary F supplementation in the primary care setting was low and that the greatest barrier to compliance was parental difficulty in remembering to give F daily.

Observed differences among states in our study could be related to state-specific FV reimbursement policies. The NC Medicaid Program has been reimbursing physicians for oral health screenings and FV applications since January 2000 (Pahel et al. 2011). Through the I-Smile program, IA started reimbursing medical providers in 2001. IN was one of last states to reimburse physicians for oral health screenings and FV application, starting January 2017. Consequently, IN had not instituted a physician-based FV program at the time of this study, which is consistent with the minimal use of F in office seen in IN in our study.

In conclusion, although the majority of children with teeth in this study did not receive F in office by age 1 y, increased F from a health care provider was associated with an increased risk for caries and with the presence of caries risk factors. Also, the majority of children had never been to the dentist, which suggests that risk factors could be alerting medical providers and/or parents and thus affecting these F recommendations.

Differences among states at the time of this study could also be related to state-specific F reimbursement policies associated with the participation of medical providers in interprofessional caries management efforts.

Author Contributions

M. Fontana, G.J. Eckert, contributed to conception, design, data analysis, and interpretation, drafted and critically revised the manuscript; M.A. Keels, contributed to design, data analysis, and interpretation, drafted and critically revised the manuscript; R. Jackson, B. Katz, S.M. Levy, contributed to conception, design, data analysis, and interpretation, critically revised the manuscript; B.T. Levy, contributed to design, data analysis, and interpretation, critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

Acknowledgments

Preliminary data from this study were presented at the 2016 American Academy of Pediatrics meeting and discussed at the International Conference on Novel Anticaries and Remineralizing Agents 3 conference in May 2017. We acknowledge the important contributions of the following individuals who served as study coordinators, data and project manager, examiners, or investigators: Jeanette Daly, Fredrica Gallack, Sue Kelly, Alex Kemper, Justine Kolker, Parul Patel, Beth Patterson, Brenda Pattison, Nancy Swigonski, Jennifer Talbert, John Warren, and Emily Yanca. This study was supported by the National Institutes of Health (grant U01 DE021412) and Clinical and Translational Science Awards: grants UL1-TR000442 (University of Iowa), 2UL1TR000433 (University of Michigan), TR000006 (Indiana University). The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

References

- American Academy of Pediatrics, Section on Oral Health. 2014. Maintaining and improving the oral health of young children. *Pediatr.* 134(6):1224–1229.
- American Academy of Pediatrics, Section of Pediatric Dentistry and Oral Health. 2008. Policy statement: preventive oral health intervention for pediatricians. *Pediatr.* 122(6):1387–1394.
- Beil H, Rozier RG, Preisser JS, Stearns SC, Lee JY. 2014. Effect of early dental office visits on dental caries experience. *Am J Public Health.* 104(10):1979–1985.
- Bhaskar V, McGraw KA, Divaris K. 2014. The importance of preventive dental visits from a young age: systematic review and current perspectives. *Clin Cosmet Investig Dent.* 6:21–27.
- Blackburn J, Morrissey MA, Sen B. 2017. Outcomes associated with early preventive dental care among Medicaid-enrolled children in Alabama. *JAMA Pediatr.* 171(4):335–341.
- Carey CM. 2014. Focus on fluorides: update on the use of fluoride for the prevention of dental caries. *J Evid Based Dent Pract.* 14 Suppl:95–102.
- Centers for Disease Control and Prevention. 2001. Recommendations for using fluoride to prevent and control dental caries in the United States. *MMWR Recomm Rep.* 50(RR-14):1–42.
- Chou R, Cantor A, Zakher B, Mitchell JP, Pappas M. 2013. Preventing dental caries in children younger than 5 years: systematic review updating USPSTF recommendation. *Pediatr.* 132(2):332–350.
- Chou R, Cantor A, Zakher B, Mitchell JP, Pappas M. 2014. Prevention of dental caries in children younger than 5 years old: systematic review to update the US Preventive Services Task Force recommendation. Evidence Synthesis No. 104. AHRQ Publication No. 12-05170-EF-1. Rockville (MD): Agency for Healthcare Research and Quality.
- Dye BA, Thornton-Evans G, Li X, Iafolla TJ. 2015. Dental caries and sealant prevalence in children and adolescents in the United States, 2011–2012. *NCHS Data Brief.* (191):1–8.

- Flood S, Asplund K, Hoffman B, Nye A, Zuckerman KE. 2017. Fluoride supplementation adherence and barriers in a community without water fluoridation. *Acad Pediatr*. 17(3):316–322.
- Fontana M. 2015. The clinical, environmental and behavioral factors that foster early childhood caries. *Pediatr Dent*. 37(3):217–25.
- Iheozor-Ejiofor Z, Worthington HV, Walsh T, O'Malley L, Clarkson JE, Macey R, Alam R, Tugwell P, Welch V, Glenny AM. 2015. Water fluoridation for the prevention of dental caries. *Cochrane Database Syst Rev*. 6:CD010856.
- International Caries Detection and Assessment System. 2017. ICDAS criteria for detecting caries [accessed 2017 Aug 16]. <https://www.icdas.org> and <https://www.icdas.org/uploads/ICDAS%20Criteria%20Document%20corrected%202013.pdf>.
- Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. 2015. Global burden of untreated caries: a systematic review and metaregression. *J Dent Res*. 94(5):650–658.
- Kranz AM, Preisser JS, Rozier G. 2015. Effects of physician-based preventive oral health services on dental caries. *Pediatrics*. 136(1):107–14.
- Kranz AM, Rozier G, Preisser JS, Stearns SC, Weinberger M, Lee JY. 2014. Comparing medical and dental providers of oral health services on early dental caries experience. *Am J Public Health*. 104(7):e92–e99.
- Marinho VC, Higgins JP, Logan S, Shelham A. 2003. Topical fluoride (tooth-pastes, mouthrinses, gels or varnishes) for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev*. 4:CD002782.
- Marinho VC, Worthington HV, Walsh T, Clarkson JE. 2013. Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev*. 7:CD002279.
- Milgrom PM, Cunha-Cruz J. 2017. Are tooth decay prevention visits in primary care before age 2 years effective? *JAMA Pediatr*. 171(4):321–322.
- Moyer VA. 2014. Prevention of dental caries in children from birth through age 5 years: US Preventive Services Task Force recommendation statement. *Pediatrics*. 133:1–10.
- Pahel BT, Rozier RG, Stearns SC, Quinonez RB. 2011. Effectiveness of preventive dental treatments by physicians for young medical enrollees. *Pediatrics*. 127(3):e682–e689.
- Quiñonez RB, Kranz AM, Lewis CW, Barone L, Boulter S, O'Connor KG, Keels MA. 2014. Oral health opinions and practices of pediatricians: updated results from a national survey. *Acad Pediatr*. 14(6):616–623.
- Rozier RG, Adair S, Graham F, Iafolla T, Kingman A, Kohn W, Krol D, Levy, Pollick H, Whitford G, et al. 2010. Evidence-based clinical recommendations on the prescription of dietary fluoride supplements for caries prevention: a report of the American Dental Association Council on Scientific Affairs. *J Am Dent Assoc*. 141(12):1480–1489.
- Tellez M, Gomez J, Pretty I, Ellwood R, Ismail AI. 2013. Evidence on existing caries risk assessment systems: are they predictive of future caries? *Community Dent Oral Epidemiol*. 41(1):67–78.
- Tubert-Jeannin S, Auclair C, Amsellem E, Tramini P, Gerbaud L, Ruffieux C, Schulte AG, Koch MJ, Rège-Walther M, Ismail A. 2011. Fluoride supplements (tablets, drops, lozenges or chewing gums) for preventing dental caries in children. *Cochrane Database Syst Rev*. 7(12):CD007592.
- Un Lam C, Khin LW, Kalhan AC, Yee R, Lee YS, Chong MF, Kwek K, Saw SM, Godfrey K, Chong YS, et al. 2017. Identification of caries risk determinants in toddlers: results of the GUSTO birth cohort study. *Caries Res*. 51(4):271–282.
- US Department of Health and Human Services. 2012. 2012 annual report on the quality of care for children in Medicaid and CHIP. [accessed 2017 Aug 16]. <https://www.medicaid.gov/medicaid/quality-of-care/downloads/2012-ann-sec-rept.pdf>.
- Weintraub JA, Hysan L. 2003. Fluoride varnish for caries prevention: comparisons with other preventive agents and recommendations for a community-based protocol. *Spec Care Dentist*. 23(5):180–186.
- Weintraub JA, Ramos-Gomez F, Jue B, Shain S, Hoover CI, Featherstone JDB, Gansky SA. 2006. Fluoride varnish efficacy in preventing early childhood caries. *J Dent Res*. 85(2):172–176.
- Weyant RJ, Tracy SL, Anselmo TT, Beltrán-Aguilar ED, Donly KJ, Frese WA, Hujuel PP, Iafolla T, Kohn W, Kumar J, et al; American Dental Association, Council on Scientific Affairs Expert Panel on Topical Fluoride Caries Preventive Agents. 2013. Topical fluoride for caries prevention: executive summary of the updated clinical recommendations and supporting systematic review. *J Am Dent Assoc*. 144(11):1279–1291.