REDUCING ORAL HEALTH DISPARITIES: WHAT CAN WE LEARN FROM SOCIAL, ENVIRONMENTAL AND CULTURAL FACTORS?

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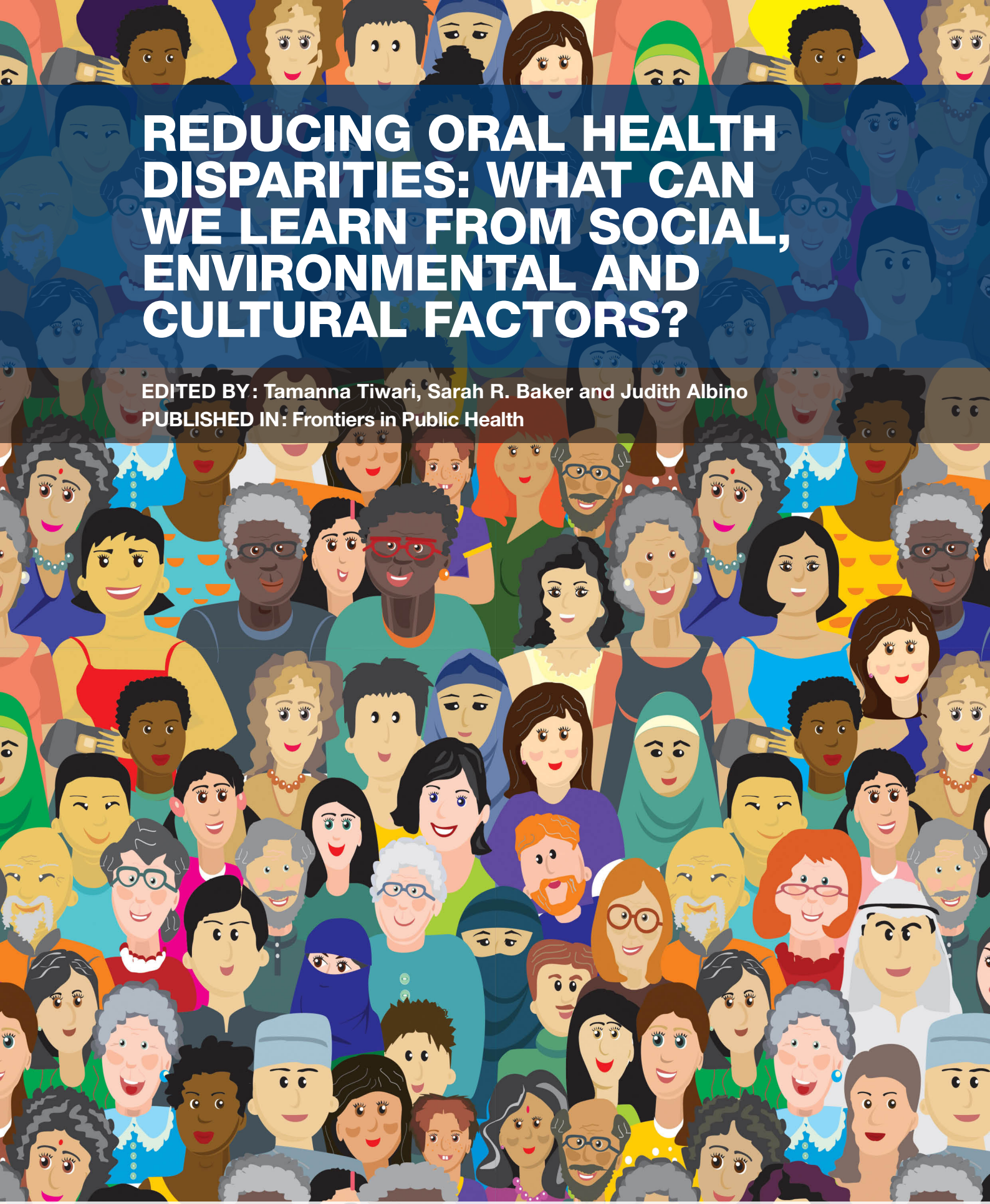

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REDUCING ORAL HEALTH DISPARITIES: WHAT CAN WE LEARN FROM SOCIAL, ENVIRONMENTAL AND CULTURAL FACTORS?

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Oral health disparities are profound worldwide, and they affect the quality of life of individuals of all age groups. Disparities in oral health are seen in racial and ethnic minorities, at different socioeconomic levels and due to differences in environment and cultural factors. Several determinants of oral health have been identified at the population, community, family and individual levels. These determinants represent a complex interplay of the social, biological, cultural and economic factors that in turn affect the oral health behaviors, environmental exposures, health care utilization. To date, biological factors related to oral diseases have received much attention in oral health research; whilst social and cultural determinants have just started to receive recognition for their role in oral disease development and progression. This research highlights that interventions designed to reduce disparities should adopt a multi-level approach in order to identify the modifiable mechanisms and target all determinants of oral health disparities.

In this Research Topic, we will focus on the role of social, environmental and cultural factors in the development and progression of oral diseases, their role in oral health disparities and interventions focusing on these factors to improve oral health and reduce disparities.

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EDITORIAL
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Editorial: Reducing Oral Health Disparities: Social, Environmental and Cultural Factors

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Keywords: oral health inequalities, community engagement, interprofessional health, oral health attitudes, preventive health

Editorial on the Research Topic

Reducing Oral Health Disparities: Social, Environmental and Cultural Factors

Inequities in oral health are profound worldwide, affecting the overall health and quality of life of millions (1). These inequalities are seen most often in association with racial and ethnic minorities, lower socioeconomic levels, in groups defined by gender or differences in environment and cultural factors, and patterns of utilization of care (2, 3). Identifying and understanding these determinants and their pathways of affecting oral health knowledge, behaviors, care utilization, and ultimately, oral health are the first steps toward finding solutions to these inequalities. To date, biological factors related to oral diseases have received much attention in oral health research, whereas the role of social and cultural determinants in oral disease development and progression has just begun to be recognized (4). This research highlights that interventions designed to reduce disparities should adopt a multilevel approach to identify the modifiable mechanisms and target all determinants of oral health disparities.

The articles included in this Research Topic emphasize the need to understand the determinants of oral health disparities, and they also explore and discuss upstream and community-level strategies to reduce the inequalities that have been created.

In Section I, unique elements of oral health inequalities associated with women and children are discussed. In most cultures, mothers are gatekeepers of the health of the entire family. Wilson et al. reports on associations of maternal attitudes, beliefs, and behaviors with the oral health of children. Wandera and Kasumba extend this topic with discussion of how cultural factors and practices affect the oral health of children in a particular region. They emphasize the importance of reporting such practices in the international community, as a strategy for identifying appropriate approaches for addressing regional inequalities.

Section II of this e-book discusses barriers faced by rural populations, racial minorities, and immigrants in accessing care, suggesting some of the reasons these populations bear the highest disease burdens. Chalmers' (Chalmers) paper discusses how lack of access to care and insurance for low-income racial minorities drives them to seek care in emergency departments, an approach that is ineffective for patients and creates an unnecessary and high financial burden for the healthcare system. Martin et al. and Minick et al. discuss how lack of insurance and geographic location has been associated with incomplete treatment and difficulties in reimbursement for orthodontic services. Brzoska et al. present similar scenarios for immigrant communities living in Germany. The authors describe several factors, such as age, demographic, social, behavioral, and health-related factors, that are associated with access to preventive dental care for immigrant populations. Doan et al. report that

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some upstream solutions, such as the expansion of public insurance for adults, have tremendously increased utilization of dental care. Such programs also provide more treatment options for patients and influence the decision-making abilities of patients, moving toward retention of teeth and reduction of extractions.

What promising solutions do we have for the challenge of reducing oral health disparities? Section III presents strategies previously seldom discussed that are beginning to emerge in the educational literature, including intentional efforts to modify and improve dental education to address oral health disparities. Moffat et al. discuss the importance of dental schools and programs in developing future ready practitioners who will be culturally competent and able to adapt to changing circumstances of the community and the world around them. One critical change that was presented by Ramos-Gomez et al. is to move the focus of training from solely surgical treatment to more prevention-oriented training, especially for the pediatric patient population. Ultimately, this approach could be expected to improve the oral health of children through better disease-related risk assessment and targeted prevention, thereby reducing the overall cost of care as well. Cooper et al. have emphasized the role of interprofessional strategies for reducing oral health disparities. Training primary care providers to conduct oral health examinations and preventive interventions, such as fluoride varnish applications and oral health education or counseling, will create an environment of future practitioners in various settings who understand the patterns and severity of oral disease in disparities populations and can help to access care for these individuals. Another approach to addressing disparities is discussed by Cidro et al. and involves engagement of the community decision-making processes related to oral health disparities. Community stakeholders can be involved in designing and implementing activities that will make these programs more acceptable, more welcomed, and more sustainable. Hornsby et al. describe the impact of oral health campaigns on the social environment of communities and motivation of families to make healthier choices.

Disparities persist across the full range of oral health issues and challenges, as reflected by the diversity of topics presented here. In the absence of definitive explanations about the root causes of many of these disparities, we are wise always to assume that some groups will be more affected than others. Similarly, some groups will be more able than others both to understand their challenges and to respond to them, including the challenges associated with accessing services or other resources to meet their health needs. To optimize our ability as caregivers and as researchers who must respond to this complex picture, we need to heighten our sensitivity to differences at all levels. This collection of reports suggests the range of responses that we will want to draw on as we continue to create that greater awareness. For example, individual approaches may be powerful for some and less so for others. Cultural expectations may point to the need for family-oriented or community-level approaches for some groups. We need to remember that one size—or type, or level—of intervention or service rarely will be right for all. A myriad of cultural, sociodemographic, psychosocial, and environmental variables creates a complex array of resources from which we can select the most appropriate information and tools to address specific oral health problems, for specific groups, at specific times and locations. Meanwhile, we must continue to learn from our many colleagues whose collective efforts will continue to add to the array of resources available to all of us.

AUTHOR CONTRIBUTIONS

All the authors contributed to the draft of the editorial and have critically reviewed and approved it.

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ORIGINAL RESEARCH
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The Impact of Maternal Self-Efficacy and Oral Health Beliefs on Early Childhood Caries in Latino Children

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Objectives: Latino children experience one of the highest rates of early childhood caries requiring interventions based on valid conceptual frameworks. The Health Belief Model has relevance as a predictor of compliance with health recommendations based on perceptions of a health condition and behaviors to avoid the condition. The model encompasses four perceptual constructs (susceptibility, severity, benefits, barriers) and, for complex conditions, includes self-efficacy as an extended model. This study evaluated individual (self-efficacy and health beliefs) and cultural (acculturation status) level factors and the inter-relationship to determine if items assessed for the Extended Health Belief Model (EHBM) were valid measures of maternal factors.

Methods: A cross-sectional study was conducted with 100 mother–child dyads at the Dental Center of Children's Hospital Colorado, Aurora, CO, USA. Participating mothers completed a survey in English or Spanish with items from the Basic Research Factors Questionnaire encompassing sociodemographic characteristics, oral health knowledge and behavior, and psychosocial measures including the EHBM. Language preference was a proxy for maternal acculturation. Children were examined to measure decayed, missing, and filled tooth surfaces. Internal consistency reliability of each subscale was evaluated using Cronbach's alpha. Convergent validity was assessed using linear regression to evaluate the association of the EHBM subscales with oral health-related measures and language preference.

Results: The benefits and self-efficacy scales reflected good reliability. Maternal education was the strongest predictor of health beliefs with significant associations for barriers, benefits, and susceptibility. Perceived benefits increased with each additional year in the household. There was a significant association between maternal oral health knowledge and higher perceived benefits and increased self-efficacy, and the same was found for higher knowledge of dental utilization which was also associated with children perceived as having increased susceptibility to early childhood caries. Less acculturated participants perceived more barriers to behavioral adherence and fewer barriers as knowledge increased. As dental utilization knowledge improved for Spanish-speaking participants, they perceived greater benefits from adherent oral health behavior compared to English-speaking participants.

Conclusion: Items assessed for the EHBM were valid as measures of maternal factors influencing children's oral health outcomes in a Latino population.

Keywords: self-efficacy, health beliefs, maternal behavior, Hispanic Americans, caregivers, dental caries, child

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INTRODUCTION

Among disadvantaged children, oral health disparities have persisted with racial and ethnic groups disproportionately affected by early childhood caries. Epidemiologic data from national surveillance studies indicate Latino children experience the highest prevalence of early childhood caries compared to other racial/ethnic groups (1–3). Models developed to improve oral health outcomes among young children have traditionally focused on biological influences with poor predictive results as up to 85% of health outcomes are associated with social determinants influencing an individual's response to adverse health conditions (4, 5). Accordingly, emphasis has extended to encompass social determinants at the caregiver level as integral influences on oral health outcomes in children including knowledge, health beliefs and attitudes, stress, self-efficacy, social network strength, and acculturation status (6, 7). Addressing the impact of social determinants among disadvantaged children requires effective interventions based on valid conceptual frameworks. Development of a validated caregiver instrument assessing a range of constructs related to children's oral health outcomes has value for the Latino population and others burdened by social inequalities in oral health. This study aimed to evaluate both individual (self-efficacy and health beliefs) and cultural (acculturation status) level factors and the potential inter-relationship between these factors/levels in mothers of Latino children.

The influence of acculturation on disparities in systemic health has been well established, yet the impact on oral health has been less studied (8). Acculturation is measured in various ways including scales (9, 10) or proxy measures that may include length of stay in the host locale, nativity, generational status, and language preference or competency (8, 11, 12). The process of acculturation involves behavioral change and integration of new beliefs with those from the original culture (13). Latinos with high acculturation status are more likely to receive health care compared to those with low acculturation (14). High acculturation status in Latino caregivers has been associated with increased dental utilization for children (15). Studies suggest that Latino children in non-English primary language households experience dental disparities with poor oral health and unmet dental needs as well as a higher need for interpreters due to language barriers (16). Low acculturation of caregivers and proximate factors including decreased education may contribute to reduced access to oral health care in Latino children (17). Latinos with low acculturation also face barriers related to decreased knowledge of insurance programs and services, cultural differences in time orientation and unfamiliarity with expectations related to scheduling health visits, and unease in accessing health care due to concerns about citizenship (18). Despite social disadvantage in U.S. immigrant children, research has minimally examined the effects of caregivers' acculturation on oral health outcomes and the relationship with social determinants (19).

Within health promotion research, the Health Belief Model (HBM) is one of the earliest and most widely used conceptual models (20, 21). The HBM posits that health behavior is determined by an individual's perceptions of a health condition and actions to avoid the condition. The model (20) includes four key constructs: perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. The HBM purports that for individuals to follow health recommendations, they must perceive: they are susceptible to developing a given disease (higher perceived susceptibility), the disease is serious (higher perceived severity), there are more benefits to engaging in adherent behavior (higher perceived benefits), and fewer potential impediments to engaging in positive health behavior (lower perceived barriers). These perceptions are potentially influenced by individual factors including demographics, knowledge, behavior, and cultural factors.

Earlier applications of the HBM were used to predict simple health behaviors, such as one-time immunizations. Eventually, the model was applied to complex health concerns requiring long-term behavioral modification. In 1988, an extended model was introduced, which combined the concept of self-efficacy with the HBM constructs. As a behavioral determinant, self-efficacy reflects the extent to which a person feels capable of successfully engaging in recommended health behaviors (22). Although the concept of self-efficacy stems from the Social Cognitive Theory (22), it was integrated (23) with the HBM because of reliability as a predictor of health behavior (24–26) and a theoretical connection to the HBM construct of perceived barriers (20, 23). The Extended Health Belief Model (EHBM) has been widely applied to a range of medical concerns in health promotion research (27–29), yet application in oral health research has been limited. The EHBM has relevance for early childhood caries, a chronic and behaviorally mediated disease requiring engagement in complex behaviors. Research has not addressed oral health disparities among Latino children relative to the EHBM and maternal influences (30). Hence, this study assessed the internal consistency and reliability of the EHBM measures in relation to individual (knowledge, behavior, and oral health outcomes) and cultural level factors (acculturation) and their importance and potential inter-relationship.

MATERIALS AND METHODS

Study Design

A cross-sectional survey was conducted with 100 Latino mother–child dyads. All recruited children were patients at the Dental Center of Children's Hospital Colorado in Aurora, CO, USA, and accompanied by their mothers. The protocol was approved by the Colorado Multiple Institutional Review Board. Participants provided written informed consent and Health Insurance Portability and Accountability Act authorization prior to study participation. The study protocol was described in an earlier report (31) and only key features are presented.

Participants

Enrollment criteria required participating mothers to be at least 18 years of age and the primary caregiver for a child under 6 years of age based on the case definition of early childhood caries as birth up to 72 months of age (32). Participating mothers were given the option to sign the consent form and complete the paper-based survey in English or Spanish and certified

translators provided study information to participants with a stated preference for Spanish. All participating children in the study received an oral examination to measure decayed, missing, filled, and surfaces in the primary dentition (dmfs). Study methods were consistent with the STROBE guidelines for cross-sectional studies.

Procedures

Participating mothers completed a questionnaire adapted from the Basic Research Factors Questionnaire (BRFQ). Development of the BRFQ survey (33) was a collaborative effort involving three Oral Health Disparities Centers funded by the National Institute of Dental and Craniofacial Research to address the excessive burden of oral disease in racial/ethnic minority populations and other disadvantaged communities. The BRFQ survey items encompassed demographics as well as caregivers' oral health knowledge and behavior, and other psychosocial measures jointly specified or developed by investigators from the Oral Health Disparities Centers: University of Colorado Denver, Boston University, and University of California San Francisco. The BRFQ is available in English and Spanish and has been administered to diverse populations by the three Oral Health Disparities centers.

Survey items related to knowledge and behavior were developed to address twelve specific content areas. These areas were identified by the cross-center Behavioral Intervention Workgroup, which was charged with specifying the counseling messages that should be incorporated into each center's clinical trials targeting disparities in early childhood caries. Key messages that were identified to guide development of survey items related to knowledge and behavior addressed the following content: (1) cavities are caused by germs, (2) baby teeth are important, (3) brush teeth every day, (4) use fluoride toothpaste, (5) help children brush up to age six, (6) limit sweet foods and drinks, (7) take your child to the dentist, (8) take care of your own teeth, (9) no bottles or sippy cups in bed, (10) do not share germs, (11) wean your child from the bottle by 1 year, and (12) look at your child's teeth once a month for spots or problems.

Oral Examination

A calibrated pediatric dentist conducted visual screenings of the children's teeth to measure dmfs. Examinations were conducted using a dental mouth mirror and an A-dec LED Dental Light (Model 576L, Newberg, Oregon 97132) attached to the dental chair. The children's teeth were brushed and dried with gauze prior to visual examination. Dental caries detection and the measurement criteria used in this study were those described by Pitts (34). The dmfs findings were recorded using an electronic dental research record system designated as CARIN (CAries Research Instrument) specifically designed for documentation of the dmfs measure.

Measures

The BRFQ survey questions related to caregiver knowledge and behavior were included and analyses used baseline BRFQ and oral exam data to assess validity of items designed to measure the five subscales addressed by the EHBM (perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and self-efficacy).

Extended Health Belief Model

Seventeen survey items measured the four main constructs from the original HBM encompassing perceived susceptibility, severity, benefits, and barriers (22, 23). Items were adapted from four sources to capture beliefs toward specific behaviors recommended as part of the intervention (35, 36). A Likert-type scale was used for all item responses and ranged from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). The average of non-missing items associated with each construct was computed, with larger numbers indicating a greater degree of each construct.

Self-Efficacy

Ten survey items measured caregivers' oral health self-efficacy (37, 38). Items were adapted from Reisine's Dental Confidence Questionnaire (39) or newly developed, and used a Likert-type scale of 1–5, where 1 indicated the caregiver was "not at all sure" she could engage in a given behavior and 5 indicated she was "extremely sure." For analysis, the average of the self-efficacy items was computed.

Oral Health Knowledge

Fourteen questions assessed caregivers' knowledge of recommended oral health behaviors. Validity of these items was described in an earlier report (40). Responses were coded as correct or incorrect ("don't know" responses were identified as incorrect). Overall oral health knowledge was measured as the percentage of questions answered correctly based on a range of 0–100%.

Oral Health Behavior

Twelve questions, which were previously validated (40), assessed caregivers' oral health behavior. For each item, responses were coded as adherent or non-adherent with adherent defined as following recommended oral health behavior as defined by the study instrument. A behavioral adherence score was computed representing the percentage of behaviors for which caregivers were adherent.

Indicators of Oral Health

Using oral examination data, a score for dmfs was computed for each child at the time of their routine dental visit at the dental clinic. Scoring for dmfs was based on the number of decayed tooth surfaces, missing teeth due to caries, and the number of filled tooth surfaces in any primary tooth. Missing teeth were scored as four surfaces for anterior teeth and five surfaces for posterior teeth. Early childhood caries was defined as a dmfs score >1 in a child under the age of 6 years.

Participant Characteristics

Items included age (mother and child), gender (child), maternal employment status and educational attainment, household income, household minors, and years in the household. In analyses, employment was coded as a dichotomous variable indicating whether the participant was employed at least part-time (32 h).

Education was coded using a dichotomous scale indicating whether the participant completed high school. Income was measured as the total income of all household members ranging from $10,830 to ≥$37,010.

Knowledge on Dental Utilization

Five items measured maternal knowledge on utilization of oral health services for their children.

Acculturation

Preference for English or Spanish as the primary language was used as a proxy measure of participant's level of acculturation. Acculturation was coded using a dichotomous scale with a participant preference for Spanish designated as low acculturation status.

Data Analysis

For descriptive statistics, categorical variables were summarized as counts and percentages and continuous variables were summarized as means and SDs. Associations between language and each variable were tested using *t*-tests and Fisher's exact tests. The associations between independent variables and dmfs were modeled using negative binomial regression. Bivariate associations and associations adjusted for age, gender, and language were tested. Data cleaning and analysis were conducted using R version 3.3.3 (41).

Participant's sociodemographic characteristics were summarized as the mean and SD for continuous variables and count and percent for categorical variables. For variables with missing data, the number of responding participants was included prior to the mean or count. Standardized item-total correlation (ITC) was used to assess internal consistency reliability between each item and its subscale. Values of 0.30 or greater were considered to demonstrate sufficient consistency with the overall subscale. The standardized form of Cronbach's alpha was used to assess overall internal consistency of each scales, where values of 0.7 or higher reflected good consistency.

Simple linear regression was used to assess the association between sociodemographic characteristics and the HBM and self-efficacy subscales. Multiple linear regression (adjusted for age, gender, and primary language) was used to test for associations between subscales and the convergent measure. Knowledge scores were modeled as predictors of the HBM and self-efficacy subscales, while behavior and dmfs were modeled as outcomes with HBM and self-efficacy as predictors. An interaction term between language and each covariate of interest was separately tested in these models. A significance level of 0.05 was used in all hypothesis tests and all confidence intervals were at the 95% level. All data cleaning and analyses were conducted in R version 3.3.3 (41). ITC and Cronbach's alpha were calculated using the psych package (42).

RESULTS

Demographic Characteristics

A total of 100 Latino mother-–child dyads were enrolled in the study, and survey data and dmfs scores were collected for 99 dyads (**Table 1**). Mean age of participating children was 4.0 + 1.1 years and 46.5% were female. Mean age of participating mothers was 31.4 + 6.6 years, 60.6% had at least a high school education, and 35.4% were employed. The median household income was $18,310, and mean years in the household was 4.3.

Associations between Demographic Variables and EHBM Subscales

Application of simple linear regression models demonstrated significant differences in the barriers, benefits, and susceptibility subscales (**Table 2**: continuous variables, **Table 3**: categorical variables). Specifically, participants with at least a high school education (**Table 2**) perceived fewer barriers, greater benefits, and greater susceptibility than participants with less education ($P = 0.004$, $P = 0.048$, and $P = 0.046$, respectively). There was also a significant association between years in the household and benefits, with the benefits subscale increasing 0.05 for each additional year in the household ($P = 0.042$).

Association of EHBM Subscales with Convergent Measures

Application of multiple linear regression models demonstrated that oral health knowledge was significantly associated with increased self-efficacy and increased benefits (**Table 4**). Additionally, knowledge on dental utilization was associated with these same outcomes as well as susceptibility. All associations were positive, demonstrating increased concern for each subscale

TABLE 1 | Demographic characteristics.

	Overall (*N* = 99)
Child's age	
Mean (SD)	99; 3.99 (1.11)
Child's gender	
Male	53 (53.54%)
Female	46 (46.46%)
Maternal age	
Mean (SD)	87; 29.54 (9.62)
Maternal education	
Less than HS	37/94 (39.36%)
HS or more	57/94 (60.64%)
Maternal employment	
Employed	35 (35.35%)
Not employed	64 (64.65%)
Household income	
$10,830–$14,569	4/41 (9.76%)
$14,570–$18,309	4/41 (9.76%)
$18,310–$22,049	5/41 (12.20%)
$22,050–$25,789	5/41 (12.20%)
$25,790–$29,529	15/41 (36.59%)
$29,530–$33,269	2/41 (4.88%)
$33,270–$37,009	4/41 (9.76%)
$37,010	2/41 (4.88%)
Household size	
Mean (SD)	91; 4.75 (1.42)
Household minors	
Mean (SD)	76; 2.66 (1.35)
Household years	
Mean (SD)	98; 4.27 (3.51)

TABLE 2 | Associations between continuous demographic variables and Extended Health Belief Model subscales.

Covariate	Term[a]	Health Belief Model (HBM) barriers	HBM benefits	HBM severity	HBM susceptibility	Self-efficacy
Education	HS or more	1.92 (1.75, 2.08)	4.39 (4.16, 4.62)	4.29 (4.05, 4.52)	3.28 (3.06, 3.51)	4.31 (4.14, 4.47)
	Less than HS	2.31 (2.11, 2.52)	4.02 (3.73, 4.31)	3.94 (3.65, 4.24)	2.91 (2.63, 3.20)	4.06 (3.85, 4.27)
	P-value	***P* = 0.004**	***P* = 0.048**	*P* = 0.075	***P* = 0.046**	*P* = 0.072
Employed	No	2.14 (1.97, 2.31)	4.23 (3.99, 4.46)	4.10 (3.88, 4.33)	3.20 (2.97, 3.42)	4.09 (3.92, 4.27)
	Yes	2.05 (1.82, 2.28)	4.15 (3.83, 4.47)	4.23 (3.92, 4.53)	3.01 (2.71, 3.32)	4.30 (4.07, 4.54)
	P-value	*P* = 0.533	*P* = 0.714	*P* = 0.507	*P* = 0.335	*P* = 0.159
Gender	Female	1.98 (1.78, 2.18)	4.22 (3.95, 4.50)	4.10 (3.83, 4.36)	3.09 (2.82, 3.35)	4.25 (4.04, 4.46)
	Male	2.21 (2.03, 2.40)	4.18 (3.92, 4.44)	4.19 (3.94, 4.44)	3.17 (2.93, 3.42)	4.10 (3.90, 4.29)
	P-value	*P* = 0.096	*P* = 0.810	*P* = 0.621	*P* = 0.638	*P* = 0.301

From univariate regression models, with HBM subscales as outcomes.
All bold font reflects significant values.
[a]*HS denotes high school.*

TABLE 3 | Associations between categorical demographic variables and Extended Health Belief Model subscales.

Covariate[a]	Health Belief Model (HBM) barriers	HBM benefits	HBM severity	HBM susceptibility	Self-efficacy
Age	0.06 (−0.06, 0.19)	−0.04 (−0.21, 0.13)	−0.09 (−0.26, 0.07)	−0.03 (−0.19, 0.14)	−0.03 (−0.16, 0.10)
	P = 0.319	*P* = 0.651	*P* = 0.262	*P* = 0.735	*P* = 0.640
HH income	−0.01 (−0.12, 0.11)	−0.04 (−0.14, 0.05)	−0.07 (−0.23, 0.10)	0.02 (−0.13, 0.16)	−0.01 (−0.14, 0.11)
	P = 0.869	*P* = 0.352	*P* = 0.408	*P* = 0.803	*P* = 0.820
HH minors	0.02 (−0.09, 0.13)	0.02 (−0.11, 0.15)	−0.04 (−0.20, 0.11)	0.06 (−0.09, 0.21)	0.02 (−0.10, 0.13)
	P = 0.689	*P* = 0.772	*P* = 0.567	*P* = 0.452	*P* = 0.750
HH size	0.01 (−0.08, 0.11)	0.00 (−0.11, 0.12)	−0.07 (−0.21, 0.06)	−0.01 (−0.14, 0.12)	−0.05 (−0.14, 0.05)
	P = 0.791	*P* = 0.976	*P* = 0.284	*P* = 0.879	*P* = 0.315
Years in HH	0.01 (−0.03, 0.05)	0.05 (0.00, 0.10)	−0.02 (−0.08, 0.03)	0.00 (−0.05, 0.05)	0.01 (−0.03, 0.05)
	P = 0.762	***P* = 0.042**	*P* = 0.346	*P* = 0.998	*P* = 0.568
Maternal age	0.02 (−0.00, 0.04)	−0.01 (−0.03, 0.01)	−0.01 (−0.04, 0.02)	−0.01 (−0.04, 0.02)	−0.01 (−0.04, 0.01)
	P = 0.098	*P* = 0.440	*P* = 0.552	*P* = 0.459	*P* = 0.198

From univariate regression models, with HBM subscales as outcomes.
All bold font reflects significant values.
[a]*HH denotes household.*

TABLE 4 | Association of Extended Health Belief Model (EHBM) subscales with convergent measures.

	Self-efficacy	Health Belief Model (HBM) severity	HBM barriers	HBM susceptibility	HBM benefits
Behavior	−0.17 (−4.85, 4.51)	1.67 (−1.87, 5.21)	0.37 (−4.69, 5.43)	−1.46 (−5.10, 2.17)	−2.82 (−6.13, 0.49)
	P = 0.944	*P* = 0.352	*P* = 0.886	*P* = 0.425	*P* = 0.094
dmfs	1.80 (−2.96, 6.57)	−2.56 (−6.16, 1.04)	0.49 (−4.68, 5.66)	2.90 (−0.77, 6.58)	2.89 (−0.49, 6.27)
	P = 0.454	*P* = 0.161	*P* = 0.853	*P* = 0.120	*P* = 0.093
Oral health knowledge	0.02 (0.00, 0.03)	0.01 (−0.01, 0.03)	−0.01 (−0.02, 0.01)	0.01 (−0.01, 0.03)	0.02 (0.00, 0.04)
	***P* = 0.016**	*P* = 0.170	*P* = 0.433	*P* = 0.415	***P* = 0.021**
Knowledge on dental utilization	0.26 (0.07, 0.45)	0.13 (−0.12, 0.39)	−0.15 (−0.33, 0.02)	0.46 (0.23, 0.69)	0.82 (0.61, 1.04)
	***P* = 0.007**	*P* = 0.310	*P* = 0.088	***P* < 0.001**	***P* < 0.001**

Presents regression coefficients and (P values) from ordinary least squares regression analyses that assessed the relationship of the independent variables (EHBM subscales) with dependent variables (convergent measures). For the oral health knowledge score, knowledge was the independent variable and the EHBM subscales were the dependent variables. All analyses controlled for age, gender, education, and income.
All bold font reflects significant values.

with increasing knowledge. No significant associations were found between the EHBM subscales and respondent behavior or dmfs.

Demographics, Scales, and dmfs Descriptive Statistics by Primary Language

Sixty-six percent of participating children had caries experience (dmfs > 0) (**Table 5**). More acculturated maternal participants had higher educational attainment ($P = 0.0342$) and dental utilization knowledge ($P = 0.0024$) compared with less acculturated participants. In relation to the EHBM constructs and expected direction of the model, more acculturated participants had higher scores for perceived susceptibility ($P = 0.0080$) and lower scores for perceived barriers ($P = 0.0002$) and higher scores for self-efficacy ($P = 0.0043$). Contrary to expectations, more acculturated maternal participants had lower scores for perceived benefits ($P=0.01951$) and borderline scores for perceived severity ($P = 0.0574$).

EHBM Subscale and Item Summary and ITC

The correlation of each item with its subscale (ITC) was considered acceptable if 0.3 or higher (**Table 6**). All EHBM items were

TABLE 5 | Demographics, scales, and dmfs descriptive statistics by primary language.

Variable[a]	Value	English	Spanish	*P*-value
Age (years)		3.94 ± 1.09	4.05 ± 1.15	$P = 0.6232$
dmfs		7.56 ± 12.11	15.20 ± 21.48	**$P = 0.0461$**
Child gender	Female	27 (45.8%)	19 (47.5%)	$P = 1.0000$
	Male	32 (54.2%)	21 (52.5%)	
Maternal age		55; 28.20 ± 9.77	32; 31.84 ± 9.05	$P = 0.0830$
Mothers education	HS or more	39 (66.1%)	18 (45.0%)	**$P = 0.0342$**
	Less than HS	17 (28.8%)	20 (50.0%)	
	(Missing)	3 (5.1%)	2 (5.0%)	
Household size		56; 4.66 ± 1.53	35; 4.89 ± 1.23	$P = 0.4426$
Household minors		44; 2.61 ± 1.42	32; 2.72 ± 1.28	$P = 0.7362$
Years in household		4.58 ± 3.67	39; 3.79 ± 3.25	$P = 0.2716$
Oral health behavior		47.13 ± 14.98	41.76 ± 16.18	$P = 0.0988$
Oral health knowledge		87.51 ± 7.65	85.67 ± 12.18	$P = 0.3995$
Knowledge on dental utilization		3.67 ± 0.51	3.15 ± 0.93	**$P = 0.0024$**
Extended Health Belief Model				
Self-efficacy		4.34 ± 0.59	3.91 ± 0.79	**$P = 0.0043$**
Perceived severity		4.29 ± 0.94	3.94 ± 0.82	$P = 0.0574$
Perceived barriers		1.89 ± 0.61	2.42 ± 0.68	**$P = 0.0002$**
Perceived susceptibility		3.34 ± 0.75	2.83 ± 1.03	**$P = 0.0080$**
Perceived benefits		4.31 ± 0.67	4.03 ± 1.24	$P = 0.1951$

All bold font reflects significant values.

[a]*Continuous variables are presented as mean ± SD. Categorical variables are presented as "count (percent)."*

acceptable except for two items (HBM3, HBM6) in the barriers subscale (ITC = 0.25, 0.39, respectively) suggesting these items were inconsistent with other items in the subscale. All other individual items were sufficiently correlated with total scores to suggest they are consistent with each subscales' concept. The benefits subscale and the self-efficacy scale showed good consistency with Cronbach's alpha values being greater than 0.7 (0.87 and 0.82). The barriers, severity and susceptibility were less than 0.7 (0.07, 0.12, 0.31). Average responses for the benefits, severity, and self-efficacy subscales were 4.20, 4.15, and 4.17 indicating areas of concern for participants. Barriers and susceptibility were less of a concern with average scores of 2.11 and 3.13, respectively.

Associations between Oral Health Knowledge and EHBM Subscales for Each Primary Language

Multiple regression models were extended to include the interaction of language and each primary predictor to determine whether the primary language affects associations between each of the knowledge, behavior, dmfs measures, and EHBM subscales (**Table 7**). Due to the large number of models, only significant results are included. Two of the models showed significant interaction effects for the primary language. The main effects model (without the interaction of language) of knowledge and EHBM barriers showed no significant association. The addition of the interaction of language resulted in a significant difference for Spanish-speaking participants in the association between knowledge and barriers, thereby suggesting that language acts as an effect modifier. Children of Spanish-speaking participants have a statistically significant negative ($P = 0.038$) association, while English-speaking participants have a non-significant but positive association ($P = 0.152$). A significant interaction was also found in the association between utilization knowledge and the benefits subscale in Spanish-speaking participants but not in English-speaking participants. For every 1 U increase in dental utilization knowledge for Spanish-speaking participants, an increase of 0.72 U was found for the benefits subscale compared to English-speaking participants. In Spanish-speaking participants, this was equivalent to an increase of 1.04 for the benefits Likert subscale for each unit increase in knowledge utilization ($P < 0.0001$).

DISCUSSION

Latino children experience one of the highest rates of early childhood caries (3), as reflected in this study with the prevalence approaching 70%. Application of the EHBM theoretical framework in relation to individual and cultural maternal factors offered insight for existing oral health disparities in young children. Per the proposed direction of the model, maternal knowledge was expected to be a predictor of HBM subscales and self-efficacy, while the HBM subscales and self-efficacy were expected to be predictors of maternal oral health behaviors and children's' oral health outcomes or dmfs (**Figure 1**). As anticipated, mothers with increased knowledge (including dental utilization) perceived that there were greater benefits from adherence with recommended oral health behavior and had greater confidence in ability to manage their children's oral health. Additionally, mothers with increased dental utilization knowledge perceived their children as more susceptible to developing early childhood caries. Contrary to expectations, Latino mothers with increased knowledge did not perceive early childhood caries as a serious condition or that children were susceptible to developing cavities and reported higher barriers. Findings were similar to other studies involving Latina mothers, in which higher knowledge did not translate to greater adherence with recommended oral health behaviors or improved oral health outcomes among children (43). Based on findings and the directional basis of the EHBM, strategies focused on maternal knowledge and behavior rather than knowledge alone may have greater potential to improve oral health outcomes.

In relation to the EHBM constructs, education was the strongest predictor of maternal oral health beliefs. Educational attainment was associated with all constructs of the EHBM excluding perceived severity. Mothers with higher educational attainment viewed their children as more susceptible to cavities, reported greater benefits to and fewer barriers to recommended oral health behavior, and were more confident in their ability

TABLE 6 | Extended Health Belief Model subscale and item summary and item-total correlation (ITC).

Scale	Item	Item label	*N*; mean (SD)	ITC
Barriers	HBM2	It would be hard to take my child for regular dental checkups	93; 1.77 (1.36)	0.70
	HBM3	It is hard to keep my child from eating sweet foods and drink	97; 2.23 (1.23)	0.25
	HBM6	I have no trouble making sure that my child's teeth are brushed the last thing before bed	96; 1.92 (1.51)	0.39
	HBM9	It's inconvenient to have fluoride varnish put on my child's teeth	87; 2.44 (1.65)	0.46
	HBM11	It's easy to make sure that my child's teeth are brushed with fluoride toothpaste twice a day	95; 2.08 (1.36)	0.50
Benefits	HBM18	My child is unlikely to get cavities if his/her teeth are brushed with fluoride toothpaste twice a day	87; 4.07 (1.31)	0.75
	HBM19	My child is unlikely to get cavities if he/she goes to the dentist for regular checkups	97; 3.88 (1.36)	0.77
	HBM20	My child is unlikely to get cavities if I keep him/her from eating a lot of sugary food and drinks	95; 4.42 (1.06)	0.78
	HBM21	My child is unlikely to get cavities if an adult helps brush his/her teeth until at age 6	96; 4.43 (1.03)	0.90
	HBM22	My child is unlikely to get cavities if a dentist or other care provider puts fluoride varnish on his/her teeth	88; 4.25 (1.16)	0.85
Severity	HBM1	Dental problems could be serious for a child	97; 4.43 (1.33)	0.44
	HBM5	Having bad teeth does not affect a child's everyday life	97; 3.79 (1.66)	0.66
	HBM8	Dental problems are not as important as other health problems	97; 4.29 (1.30)	0.71
Susceptibility	HBM4	Most children get cavities	92; 3.55 (1.36)	0.62
	HBM7	My child will probably get cavities in next few years	91; 2.08 (1.00)	0.56
	HBM10	Children can get cavities as soon as there first tooth comes in	90; 3.78 (1.52)	0.59
	HBM12	It is not likely that my child will have problems with his/her teeth	88; 3.07 (1.32)	0.51
Self-efficacy	SE1	Carefully check your child's teeth and gums every month for spots and problems?	93; 3.94 (1.17)	0.53
How sure are you that you can …	SE2	Take your child to the dentist for regular checkups?	99; 4.78 (0.71)	0.64
	SE3	Always use fluoride toothpaste when brushing your child's teeth?	93; 4.41 (1.01)	0.61
	SE4	Make sure that your child does not eat or drink anything other than water after the teeth and gums are cleaned at bedtime?	97; 4.26 (1.13)	0.64
	SE5	Keep your child from eating frequent sweets? (cake/candy)	97; 3.86 (1.19)	0.63
	SE6	Keep your child from putting anything in his/her mouth that has been in someone else's mouth?	98; 3.84 (1.30)	0.75
	SE7	Have fluoride varnish put on your child's teeth by a dentist or other health care provider?	94; 4.07 (1.10)	0.47
	SE8	Keep your child from drinking sugary drinks like soda, pop or Kool-Aid?	98; 3.67 (1.26)	0.67
	SE9	Avoid putting your child to bed with a bottle or sippy cup with anything other than water in it?	97; 4.60 (1.01)	0.61
	SE10	Make sure your child's teeth are brushed twice a day?	98; 4.38 (1.01)	0.67
Scale	Cronbach's alpha	Mean (SD)		
HBM barriers	0.07	2.11 (0.69)		
HBM benefits	0.87			
HBM severity	0.12			
HBM susceptibility	0.31	3.13 (0.90)		
HBM self-efficacy	0.82	4.17 (0.71)		

ITC of 0.30 or higher was considered to reflect an acceptable degree of association between an item and the total score for its subscale. Cronbach's alpha of 0.70 or higher reflected an acceptable degree of consistency among items in a subscale.

TABLE 7 | Associations between oral health knowledge and Extended Health Belief Model subscales for each primary language.

Outcome	Covariate	Comparison	Estimate	Lower	Upper	*P*-value
Health Belief Model (HBM)—barriers	Knowledge	English slope	0.02	−0.01	0.04	$P = 0.152$
		Spanish slope	−0.02	−0.03	−0.00	$\mathbf{P = 0.038}$
HBM—benefits	Utilization knowledge	English slope	0.32	−0.05	0.70	$P = 0.088$
		Spanish slope	1.04	0.80	1.29	$\mathbf{P < 0.001}$

All bold font reflects significant values.

to engage in optimal oral health behavior. Latina mothers with higher educational status, however, did not perceive cavities as more serious. Variation in the severity subscale may be related to cultural influences and practices in Latino mothers. In previous qualitative studies, Latina mothers reported they did not perceive that dental decay was a condition that affected young children (43, 44). Findings highlight the importance of identifying and addressing specific cultural beliefs that are counter to optimal oral health in young children.

Study outcomes also reflected that the duration in the household significantly influenced maternal oral health beliefs. Longer durations in the household positively influenced maternal perceptions regarding greater benefits to adherence with recommended oral health behaviors. Other studies suggest that frequency of residential moves including immigrations affect children's oral health outcomes (4). Dislocations in residence decrease stability within families and disrupt access to health-care services and benefits. Specific guidance on maintaining a dental home for

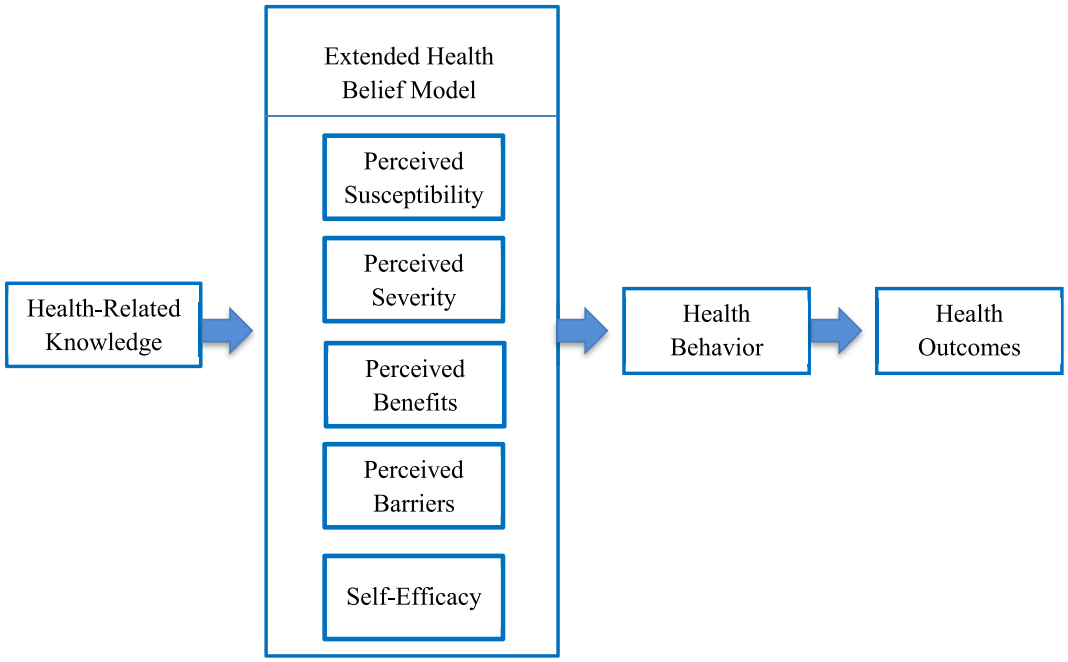

FIGURE 1 | Extended Health Belief Model.

children despite changes in household duration is recommended. Outcomes reinforce the importance of integrated care systems that facilitate access to care and services for disadvantaged children and families.

The inter-relationship between the individual and cultural level factors for participating mothers demonstrated that less acculturated mothers (Spanish-speaking) overall perceived greater barriers to adherence, but perceived fewer barriers as their knowledge increased. In addition, as dental utilization knowledge improved for Spanish-speaking mothers, they perceived greater benefits to adherent oral health behavior compared to English-speaking mothers. Significant findings were not found for maternal behavior and early childhood caries in relation to the EHBM constructs and acculturation status or their inter-relationship. Negative health outcomes may be explained by the concept of inverse care law. The premise of inverse care law implies that individuals and groups with lower health needs experience greater benefits from care compared to those with a higher health needs (45, 46). Other contributory factors include a higher prevalence of comorbidities involving psychological distress, health literacy, and fatalism. Inability to manage multiple comorbidities may lead to a more selective focus that may not include dental caries in children (47). Low caregiver health literacy has been associated with reduced ability to accomplish child-related tasks (48). Enhancing caregivers' health literacy and other beliefs may improve use of health-care systems and oral health outcomes for children (30, 44).

In summary, the results from this study suggested that the items assessing the EHBM theoretical constructs are valid as measures of maternal factors influencing children's oral health outcomes in a Latino population. Study limitations included a smaller sample from a clinically based population in a single location that may not reflect all Latino communities. The cultural and language orientation of participants may have influenced responses to the translated items due to subtle differences in interpretation. Familiarity with the community, use of language consultants, and pilot studies may enable more accurate responses with translated instruments (30). Additional studies are warranted to determine whether these measures fit expectations regarding the relationship of these theoretical constructs over time. Testing of these measures among a range of Latino groups as well as other socially disadvantaged groups will lend additional support to these measures.

AUTHOR CONTRIBUTIONS

All authors (AW, MM, and TT) have made substantial contributions to the design of the work, analysis of the data, and revision of the work and provided final approval. All authors agreed to be accountable for all aspects of the work to ensure questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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The Sex and Gender Intersection in Chronic Periodontitis

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Periodontitis, a complex polymicrobial inflammatory disease, is a public health burden affecting more than 100 million people and being partially responsible for tooth loss. Interestingly, periodontitis has a documented higher prevalence in men as compared to women signifying a possible sex/gender entanglement in the disease pathogenesis. Although relevant evidence has treated sex/gender in a simplistic dichotomous manner, periodontitis may represent a complex inflammatory disease model, in which sex biology may interfere with gender social and behavioral constructs affecting disease clinical phenotype. Even when it became clear that experimental oral health research needed to incorporate gender (and/or sex) framework in the hypothesis, researchers overwhelmingly ignored it unless the research question was directly related to reproductive system or sex-specific cancer. With the recognition of gender medicine as an independent field of research, this study challenged the current notion regarding sex/gender roles in periodontal disease. We aimed to develop the methodological and analytical framework with the recognition of sex/gender as important determinants of disease pathogenesis that require special attention. First, we aim to present relevant sex biologic evidence to understand the plausibility of the epidemiologic data. In periodontitis pathogenesis, sex dimorphism has been implicated in the disease etiology possibly affecting the bacterial component and the host immune response both in the innate and adaptive levels. With the clear distinction between sex and gender, gender oral health disparities have been explained by socioeconomic factors, cultural attitudes as well as access to preventive and regular care. Economic inequality and hardship for women have resulted in limited access to oral care. As a result, gender emerged as a complex socioeconomic and behavioral factor influencing oral health outcomes. Taken together, as disease phenotypic presentation is a multifactorial product of biology, behavior and the environment, sex dimorphism in immunity as well as gender socio-behavioral construct might play a role in the above model. Therefore, this paper will provide the conceptual framework and principles intergrading sex and gender within periodontal research in a complex biologic and socio-behavioral dimension.

Keywords: sex, gender, periodontitis, gender inequality, sex biology

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INTRODUCTION

Periodontitis, a complex polymicrobial inflammatory disease, affects more than 30% of the US population (approximately 100 million people) (1) and is partially responsible for full edentulism in 1/4 of US adults 65 years of age or older (2). Therefore, understanding the disease and determining the most effective therapy it is a priority, as highlighted by the 2020 Healthy People Objective (OH-5),

which aims to reduce the number of adults with moderate or severe periodontitis.

Interestingly, periodontitis has a documented higher prevalence in men (~57%) compared to women (~39%) (1, 3), signifying a possible sex/gender bias in disease pathogenesis. Important contributing disease factors, such as diabetes and smoking, do not seem to significantly differ between genders, as the prevalence of diabetes is 9.8% in men and 9.2% in women (4), whereas the prevalence of smoking is 18.8% in men and 14.8% in women. Furthermore, classic studies of the natural history of periodontal diseases have been conducted as single-gender studies focusing only on men (5–12). Hence, their findings have limited validity for half of the world's population and therefore questionable generalizability. Recent evidence on periodontal risk assessment has revealed that gender plays a critical role in periodontal risk (13). Specifically, when the analysis is limited to the severe periodontitis category, men are at higher risk compared to women (13). These data also confirmed the role of smoking and diabetes as contributory factors in the disease process (13).

Although relevant evidence has treated sex/gender in a simplistic dichotomous manner (14), periodontitis may by a complex inflammatory disease model, in which sex might interfere with the gender social construct, affecting the disease clinical phenotype and therapeutic response (14–16). Yet, gender bias has not previously been evaluated in periodontal trials.

As defined by the Institute of Medicine, sex is a biological variable that is determined by the chromosomal structure (male [XY] or female [XX]) as well as reproductive organs and functions assigned by chromosomal complement (17). However, gender is fluid, self-perceived, and determined by responses to social institutions as well as influenced by gender roles, social expectations, and sexual identity (18, 19).

A series of historical events, medical evidence, and political decisions influenced the attention on research hypotheses exploring sex/gender differences. Undeniably, following the atrocities of WWII as related to unethical medical experiments on prisoners in concentration camps, there was an urgent need for a regulatory framework for the protection of human subjects including women and children (17). As a result, women were not allowed to participate in clinical trials based on: (1) the general assumption of there being "no difference" between women and men and (2) the notion that including women in trials would confound study outcomes with unnecessary hormonal "noise" and fluctuations. As the understanding of the biologic implications of sex and socio-behavioral dimensions of gender evolved, it became apparent that certain population groups might require a separate focus. Consequently, in 1986, the NIH encouraged (but did not require) the inclusion of women in clinical studies (17). Unfortunately, within a few years, the NIH realized that the suggestion was not regularly implemented in clinical studies (20). Thus, after establishing the NIH Office of Research on Women's Health, the Revitalization Act (P.L. 103-43) became law to ensure that women and minorities would be included in clinical research. A few years later, the NIH updated its guidelines, requiring a description of analytical plans by sex/gender for each study. In 2015, the NIH developed a policy on the consideration of sex as a biological variable, requiring studies to adopt the appropriate terms and to also justify single-sex research protocols (21).

With the current emphasis placed on sex/gender as determining factors in preclinical and clinical studies of health and disease by the NIH (21), European Commission (22), and Canadian Institutes of Health (23), medicine has taken a more critical look at existing evidence by investigating differences between sex/gender in the diagnosis, prevention, and treatment of several diseases. As a result, medical research focusing on sex/gender disparities has significantly increased in recent years (24). For example, a US Drug Safety report revealed that drugs that were withdrawn between 1997 and 2000 presented a greater risk for women than men (25), highlighting the gender bias in required drug trial designs. Quality analysis of medical trials has confirmed that a gender bias exists in many large clinical studies, such as the Physician's Health Study on aspirin and Multiple Risk Factor Intervention Trial (MRFIT), which enrolled no women (26). In addition, the EU-funded project EUGenMed examined, in a multidisciplinary manner, the roadmap for the inclusion of gender aspects in European biomedical and health research (25) (EUGenMed 2015). Collectively, these efforts signify that the field of gendered medicine has recently evolved with the gradual increase of research publications, particularly in cardiology, since the 1990s (24).

Even when it became clear that experimental oral health research needed to incorporate the gender (and/or sex) framework in hypotheses, researchers overwhelmingly ignored this information unless the research question was related to the reproductive system or sex-specific cancer. With the recognition of gender medicine as an independent field of research, this paper challenges the current notion regarding the sex/gender role in chronic periodontitis pathogenesis (27), given the strong epidemiological evidence suggesting a difference in the prevalence of periodontitis between men and women, which remains constant in every disease stage and under various case definitions (1). This disparity has been attributed to gender behavioral factors, which received significant weight, with the goal to maintain the assumption of similar therapeutic responses between genders. In this process, several factors have been ignored or have not been extensively evaluated, including sex biology and gender behavior, which have been increasing recognized in complex chronic and/or immune disease models.

Given that sex and gender have been significantly understudied in the field of periodontology, we aimed to develop a methodological and analytical framework that recognizes sex/gender as important determinants of periodontitis with the goal to address gender bias in clinical as well as preclinical studies in periodontology.

Sex Biology in Periodontitis: A Microbiome–Host Approach

Consistent epidemiological data have highlighted higher periodontitis prevalence in men as compared to women (28, 29). Given that periodontitis is a complex inflammatory disease of microbial etiology, at the microbial level, the sex hypothesis might be tangled with the immune-regulatory dimension. Although in

infectious diseases, evolutionary evidence has consistently supported a male disadvantage in prevalence, outcomes, and survival rates (30), these findings could not be directly extrapolated to periodontitis due to its chronic inflammatory profile triggered by bacteria. Hence, the hormonal, genetic, and epigenetic influence on immunity has remained unclear and possibly understudied.

In periodontitis pathogenesis, sex dimorphism might be implicated in disease microbial etiology possibly modifying the bacterial biofilm, as well as the host immune response (27, 31). Indeed, limited data from earlier studies have shown significantly higher odds for harboring salivary and subgingival periodontal pathogens, such as *Prevotella intermedia*, in men than in women (32, 33). Similarly, sex-specific differences have also been observed in the gut microbiome (34), where *Bacteroides* have a lower abundance in women than in men. When fecal microbiota data were analyzed according to gender, higher levels of *Bacteroides* and *Prevotella* species were observed in men than in women (35). Following this direction, recent evidence has revealed a diverse interaction between microbes and host sex hormones (36) with microbes manipulating and utilizing sex hormones to survive. More specifically, in mouse models, there has been a direct shift in hormonal levels (i.e., production of androgens in female mice) after transferring gut commensal bacteria from male to female mice (37). Other groups have discovered sex-distinct signatures in the gut microbiome, which after being mediated by testosterone, could upregulate a certain immune response and affect the initiation and progression of diabetes type 1 in mouse models (38). In similar models, microbes could use sex steroids for growth as well as transmission and, therefore, explain the evolutionary process of microbial survival (36).

As the role of inflammation in periodontal pathogenesis has evolved, the host immune response has taken on an important part (39, 40). Therefore, sex biology could be explored as a modifying factor of innate and adaptive responses possibly manifesting a diverse susceptibility to the disease (15, 27, 31). Sex steroids and X-linked genes have been proposed to be the main mechanisms that alter immune function (41–43). Although periodontitis has primarily been associated with X-linked genetic disorders, the reported evidence is of low quality and not conclusive (44). Therefore, in this report, we aim to examine basic evidence regarding the sex influence on the immune response in genetic or autoimmune disease models.

Sex chromosomes play an important role in mediating the differences in the immune response, with X-linked genes regulating pattern recognition receptors and cytokine production, as well as transcriptional factors (41). The X chromosome's significance in immunity was confirmed in inherited syndrome models (i.e., Klinefelter), in which the extra X chromosome in men resulted in an immune response similar to that in women (with a high CD4 T cell count, high CD4/CD8 ratio, and higher immunoglobulin levels) compared to XY men controls (45). On the contrary, studies on women with Turner syndrome (X monosomy) have shown lower T cell and B cell levels as well as low IgG and IgM levels, weak PMN chemotaxis, and low CD4/CD8 ratio as compared to women with chromosomal XX (43, 46). In parallel, studies have shown polymorphisms in sex chromosome genes that encode receptors for anti-inflammatory IL-4, IL-10, and IL-12 (30, 41, 43) indicating a sex bias in pro- and anti-inflammatory immune responses. Certain polymorphisms in sex chromosomal and autosomal genes have also been hypothesized to affect immune responses, including cytokine production, pattern recognition receptors, and transcriptional factors (15), and contribute to the differences between sexes. Additional lessons were learned from the autoimmune disease models, where a clear connection to the X chromosome might be implicated in the loss of the immune tolerance (47).

In addition, hormonal mediators of the immune response (i.e., estrogens, progesterone, and testosterone) have been shown to affect innate and adaptive immunity (48). In general, several studies have demonstrated the immunosuppressive role of testosterone and progesterone, as well as the immune-enhancing impact of estrogens (48), which collectively explain the high infection rate in males combined with the high autoimmune disease prevalence in female mammals (41, 43, 48, 49). In human autoimmune disease models, women represent more than 80% of cases (41). Interestingly, in animal autoimmune models, the incidence of autoimmune diseases is increased by male castration and decreased by female ovariectomy (50). Animal and human studies have revealed that increased estrogen levels lead to higher neutrophil numbers and enhanced phagocytosis (51). Furthermore, female macrophages exhibit higher levels of toll-like receptor 7 expression, with higher phagocytic activity (43), and produce more interferon a (TNF-a). An additional mechanism for sex dimorphic characteristics is involved in the function of TLR4, which in animal and *in vitro* models has shown greater expression in males than females, followed by increased production of pro-inflammatory cytokine, leading to a more pronounced inflammatory response (52).

Estrogens have demonstrated a bi-potential effect on the immune response, with low doses enhancing pro-inflammatory cytokine production and high or sustained doses reducing pro-inflammatory cytokine production (15, 53). Female animal models have also demonstrated an increased Th2 immune response, with the IL-4, IL-5, and IL-10 levels confirming the possible inhibition of disease progression (27), as well as increased proliferation of M2 macrophages amplifying the immune response (54). Although women have higher levels of T lymphocytes than men, their adaptive immunity is predominantly driven by B cells and CD4 Th2 cells (27). Although the increased antibody production in women determines the response to infections and vaccination, it also increases the risk for autoimmune diseases such as Sjogren's syndrome, multiple sclerosis and others (41, 55). There are some indications that while Th2-mediated diseases tend to be more prevalent in women (43), Th1-mediated autoimmune diseases, such as cardiomyopathy, may be more prevalent in men (54). In men, experimental evidence has shown that testosterone increases monocyte production of IL-12 in response to LPS stimulation, with increased Th1 differentiation and NK cell activation (56, 57). In addition, regulatory T cells, which have anti-inflammatory properties, have been found at increased levels in men (30), although there have been some contradictory results in mouse studies. Although the sex-mediated immune

pathways were not verified in periodontitis, these established concepts would need to be examined in animal and human models of periodontitis.

In fact, in an effort to apply the above basic principles to the periodontal hypothesis, limited clinical experimental data have supported a higher concentration of the IgG antibody against *Porphyromonas gingivalis* in women than men, similar to chronic periodontitis (58). In summary, given that the innate immune response might be more regulated in women (53) and more intense in men, women tend to be more effective at pathogen clearance compared to men. In addition, exposure of NK cells to estrogens increases INF-γ production (59), which has been shown to play a controversial role in periodontitis, with *in vivo* studies confirming an association with bone resorption and *in vitro* studies showing an inhibitory role in osteoclastogenesis (60, 61). At the final level of inflammation resolution, there are indications that women may produce higher levels of resolvins due to increased synthesis of long-chain n-3 PUFA, leading to more effective periodontal inflammation resolution (27).

Given the sex influences on microbial communities and immune functions, the host–microbial hypothesis in periodontal pathogenesis might need to be examined under the sex lens in order to achieve an unbiased understanding.

Gender As a Socio-Behavioral Construct

Gender oral health disparities have been explained by socio-economic factors and cultural attitudes, as well as by access to preventive and regular care (62). There is a clear distinction between the terms "sex" and "gender." While sex refers to the biological factors that are directly related to genetics, physiology, and anatomy, including the reproductive system, gender relates to social roles, behaviors, and attitudes (63, 64). More importantly, gender identity, as a product of perception, social influence, and relations, has been frequently reduced to a binary measure (64), which tends to simplify complex social interactions. Therefore, although animal models may be able to capture sex differences, gender differences, as socio-behavioral processes, have been more difficult to capture (65).

In this context, efforts were made to define gender after considering several psychosocial variables that determine gender roles, gender identity, and relations, as well as social norms (65). Therefore, composite gender scores were developed to capture the dimension of the socio-behavioral constructs, to measure masculine and feminine personality characteristics and to assess the manner in which they might affect disease presence and outcomes (66). Using this methodology, the association between gender-related factors and biological sex was investigated, and seven gender-related variables, which were able to independently predict sex, were confirmed, including the household primary earner, income, and housework weekly hours, status of the primary person responsible for doing housework, stress levels at home, and Bem Sex-Role Inventory (65, 66). This methodology recognized the intersection between sex and gender, as well as their relationship with cardiovascular outcomes. In summary, femininity was associated with high levels of anxiety and depression, smoking, diabetes, hypertension, and poor cardiovascular outcomes. Interestingly, patients with feminine personality traits were less likely to be prescribed as antihypertensive and be prescribed statin medications.

Gender inequality has affected economic and health outcomes internationally for women and children (67, 68). Women experience a higher incidence and severity of poverty than men ("feminization of poverty") (69, 70), as confirmed by the Institute for Women's Policy Research (IWPR) gender poverty report (71). The International Monetary Fund recently demonstrated that income inequality is associated with gender inequality after controlling for confounders (72). Interestingly, this association is true for all countries, with advanced countries showing a stronger correlation between inequality and economic participation, while in low-income countries, inequality of the opportunity for education and political empowerment and health appear to be the most important barriers to income distribution (72). Ironically, although women represent half of the world's workforce, they only generate 37% of the global gross domestic product (73).

Economic inequality has been a recognized determinant of health care that affects access to health care, including dental care (69, 74). Indeed, disparities resulting from economic inequality are greater in the US compared to other wealthy countries (67, 75, 76). Although the Affordable Care Act (ACA) aimed to expand coverage, 39% of below-average Americans still avoid seeing a doctor due to cost (75). In addition, fewer women are uninsured compared to men, but women with health insurance are responsible for higher out-of-pocket costs compared to men, regardless of their insurance type (Medicare or employer-sponsored) (75). The Agency for Health Care Research and Quality has produced data on disparities in health-care quality according to which women are significantly more likely than men to be delayed or unable to obtain medical and dental care or prescription medication (77). As timely care delivery has been shown to reduce mortality and morbidity (78), this finding is significant and could result in poor chronic disease outcomes. The disparities are more important when they intersect with race and ethnicity. Hispanic women experience a statistically significant delay in care compared to non-Hispanic women (77). Another important finding highlights the fact that 2% of women, compared to 0.9% of men, receive prescriptions for at least one medication that should be avoided due to adverse events (77). Based on National Health Medicaid data (1997–2011) (79), when assessing dental care access, approximately 20% of women, as opposed to 15% of men, "did not receive dental care due to cost" (79). In fact, economic inequality has resulted in only 38% of middle class Americans having annual dental visits compared to 55% of high-income Americans (80). Even among high-income Americans, income measurements were negatively but significantly correlated with the number of missing and decayed teeth only in women (80). Based on the above data, gender economic inequality has been found to directly affect access to care and tooth loss (80).

Despite the continuous increase of health-care costs, preventive care utilization has always been a goal for cost reduction. The factors that predict the dental care utilization rate include gender, high income, and overall health perception (74). In the pre-health reform era, women utilized preventive care more frequently than men, although still at low rates and often only for acute care (74). In addition, cultural norms influence men's overall low primary

care service utilization because masculinity drives the expectation for men to stay strong and to not need care (74).

After implementation of the ACA, followed by the expansion of adult Medicaid in 27 states, adult dental benefits increased by 2–6% points; however, the changes did not reach the level of significance (81). Specifically, it has been projected that by 2026 (assuming that the ACA remains in place), approximately 45% of the population will use dental preventive services, with an annual growth rate of 0.5% (81). With preventive services dominating the utilization model, treatment service will decline, following the demographic shifts in the population.

Risk perception has also been affected by gender, with different concern levels on disease risks or treatment decisions observed (62). As a result, attitude and behavior related to health promotion and compliance might be affected. In the same context, women have been consistently found to demonstrate better oral hygiene habits than men. Oral health-related behaviors in women, including brushing and flossing, have occurred at higher rates than in men (62). However, given all of the above data, the differences in oral hygiene might be a simplistic explanation for the differences in disease presentation between women and men.

In conclusion, gender emerges as a complex socioeconomic and behavioral complex factor that certainly affects access to care, treatment choices, and outcomes; therefore, it needs to be appropriately studied and analyzed.

CONSIDERING SEX/GENDER IN PERIODONTAL RESEARCH

Recent efforts by research organizations (NIH, FDA, and CIHR) (21–23, 82, 83), the International Committee of Medical Journal Editors (ICMJE) (84), the European Association of Science Editors (85, 86), and others (Gender Innovations, Stanford University) (63) have emphasized sex and gender and developed guidelines and checklists to address their intersection. Because of this international effort, oral health and periodontal research may need to establish a framework to produce diverse and generalizable knowledge, reduce health disparities, avoid gender bias, and improve oral health therapeutic interventions without any *a priori* assumptions (64, 87).

The above goal is realistic because the developed checklists aim to help researchers to develop their strategies and analytical plans, in terms of sex and gender, after they first determine the importance and relevance of sex/gender or the manner in which they might intersect (88). As emphasized above, sex remains a relevant factor in the preclinical research (89) setting with animal, tissue, and cell models, and must also be addressed at the preclinical level, as the NIH has recently required (21).

Furthermore, to facilitate extensive and reliable literature searches, search engine tools were developed with the goal of limiting biomedical searches to sex- and/or gender-related references in a predictable and complete manner (62, 90). Moreover, after analytical plans have been designed, there are certain recommendations for the presentation of study populations at baseline to reflect the representation of men and women, with special consideration given to age, ethnic/racial background, and socioeconomic status. It is important to have appropriate statistical methods to analyze sex/gender differences at baseline, as well as at the end of the intervention. Result disaggregation and reporting will enable the preclinical and clinical research community to evaluate treatments and better understand therapeutic options by sex/gender. When randomly reviewing periodontal randomized controlled trials, we found that, at baseline, the trial demographics were appropriately presented; however, the outcomes were never disaggregated in terms of gender (Ioannidou, unpublished data). This finding highlights the lack of evidence for periodontal treatment responses by gender.

In addition to the above data, journal editors and publishers may need to reinforce the ICMJE guidelines, which require appropriate use of the terms sex/gender in scientific publications, report of the sex/gender of participants, report of the sex of animals or cells, and discussion of the influence of sex/and or gender on the study findings (84, 85). These guidelines offer transparency in reporting but also provide an interpretation of results with an aim toward generalizability to the general population. The guidelines also emphasize that when studies are conducted on single-sex/gender populations, the reason should be justified and reflected in the study title to avoid misleading interpretations.

Given the role of sex and gender in chronic periodontitis pathogenesis, periodontal researchers need to "set it up" and extensively explore their role and effects on disease pathogenesis, clinical presentation, and therapy. Therefore, when considering future study designs, periodontal researchers must apply principles that allow for high levels of external validity that reduce sex/gender bias. For this purpose, researchers must overcome historical sex/gender assumptions, recognize the potential implications of sex/gender on the hypothesis, and address these variables appropriately in their study designs.

AUTHOR CONTRIBUTIONS

The author has conceived, designed, and conducted the study.

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REVIEW
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"Ebinyo"—The Practice of Infant Oral Mutilation in Uganda

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Infant oral mutilation (IOM) is a traditional method of extracting un-erupted teeth practiced in several Sub-Saharan African countries including Uganda. This practice is referred to as "ebinyo" by Bantu-speaking Ethnic groups, though it has several terms depending on cultural group and researcher. The un-erupted tooth is gouged out as a cure for medical symptoms in infants that include high fevers and diarrhea. The spreading of IOM practice in African populations is blamed on poor health literacy with regard to the common childhood illnesses. One study in Uganda revealed that adverse cases following IOM seen in the hospital peaked in tandem with the malaria and diarrheal disease cases. This paper is a review of the practice with a particular focus on Uganda as presented in literature compiled from PubMed, Dentaid, Google Scholar, Local Uganda sources, and the authors' observations. The paper explains reason for the persistence of the practice, and to further inform on IOM to health practitioners who were previously unaware of the practice.

Keywords: infant oral mutilation, ebinyo, traditional healers, Uganda, canines

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INTRODUCTION

Traditional methods of treating illnesses are still practiced in several parts of Africa (1–3). These traditional methods may not be scientifically explainable, yet societies continue to apply them as a means to prevent and treat diseases. World Health Organization reports that 80% of African populations use traditional medicine for cultural and economic reasons as their primary source of care (3).

Traditional methods of treatment may be injurious as has been observed by several authors on a practice referred to as infant oral mutilation (IOM). In the literature, authors also refer to IOM by other terms that include *tooth extirpation*, *germectomy*, *deciduous canine buds enucleation*, *nylon teeth*, and *false teeth* (4–7). The most common term for IOM practice is Ebinyo which is derived from the Bantu- languages and loosely translates to "false teeth."

Infant oral mutilation is where un-erupted teeth, usually in the position of canines, are gouged out by a non-formally trained person. The raised areas on the infants gum are identified and then using a sharp instrument the soft un-mineralized tooth is extracted as the "offending worm." The range of rudimentary that may be used include bicycle spokes, hot needles, pointed knives, nails, and other sharp objects (5, 6, 8–10). The procedure is carried out in the belief that it will prevent or treat symptoms such as fevers or diarrhea seen in an infant (5, 7–10).

Gollings (active document) reports that the earliest literature report on the practice was found in tribes of the Nilotic Sudan in 1932. The practice is now reported to have spread to several Sub-Saharan Africa countries that include Uganda, Chad, Sudan, Ethiopia, Somalia, DR Congo, Kenya, Tanzania, Rwanda, and Burundi. Studies also report individuals migrating from these African nations may continue this practice in Europe, Australia, and the Americas (11–14).

METHOD

This paper is a review of IOM in Uganda. It has been compiled from PubMed, Dentaid, Google Searches, Local Uganda sources, and supplemented by anecdotal evidence from the authors. The search terms were as follows: Infant oral Mutilation, Ebinyo, Ebino, Canine extirpation, and enucleation. The authors reviewed articles, media presentations, and reports.

HISTORY OF IOM IN UGANDA

Uganda is a landlocked country located in the Eastern part of Africa. Uganda is bordered by South Sudan to the North, Kenya to the East, DR Congo to the West, and Rwanda and Tanzania to the South. Uganda gained its independence from Britain in 1962. There was a military coup in 1971, followed by a period of instability in the country up until 1986; as a result, this period has scarce documented research.

The current population of Uganda is approximately 40 million. Uganda has a rapid population growth, reported as increasing from 9.5 million in 1969 to 35 million in 2014 (15). Only 25% of the population lives in urban areas. Uganda has several ethnic groups, each with their own language, customs, and traditional practices (16). These ethnic groups can be grouped into Bantu speaking and non-Bantu speaking, with the former living mainly in the Southern regions while the latter living in the Northern regions.

The first mention of IOM in Uganda is in a study carried out in 1969 by Pindborg (17). They reported that 16.1% of the children of the Acholi tribe of Northern Uganda had missing canines due to IOM. The dental mutilation gave credence to the existing myth to extract teeth as a remedy to childhood fevers.

In 1971, Halestrap who had observed some dental anomalies in Uganda populations caused by customary and superstitious practices assumed they were on the decrease as modern health practices were being adopted. He then proceeded to document the practices so as to keep a written record under the assumption that the practices would be disused in later years (18). This author clearly described the regional distribution of the different traditional practices in Ugandan cultural groups, stating that the "deciduous teeth enucleation" was only practiced in the Northern region of the Uganda and not in any other parts. This is in concordance with the findings of Pindborg as a practice of the Northern region. When the country was more stable, in 1989, the Uganda Ministry of Health carried out a survey and reported 95% of a focus group they studied in a Southern district of Uganda had heard of Ebinyo, thereby indicating a spread (19).

TRENDS OF IOM PRACTICE IN UGANDA

Infant oral mutilation is currently reported all over Uganda. In 40 years, IOM prevalence is now reported by Tiromwe et al. (20) to have almost tripled to over 50% in the Northern district that Pindborg studied (17). Furthermore, the tribe of the Baganda that had no traditional practices interfering with their normal dentition in 1971, in more recent studies is implicated as having introduced IOM to the South Western regions (9, 10). Literature further states that elder persons are more likely to report IOM as a new condition, while the younger people believed the practice always existed (5, 9, 10). Similarly, the authors (Betsy Kasumba and Margaret N. Wandera) have observed dental consultations at conventional clinics are more likely from grandmothers rather than mothers before taking a child for "Ebinyo" treatment. IOM has been found to be done more in rural, than urban children, and more likely to be done on children who were under the care of a caretaker than a parent (20). However, the levels in urban areas are considerably high, as reported in a study of children attending child clinic in the Capital city Kampala in 2007 where 24% who had undergone IOM.

IMPACTS OF IOM

The adverse impacts of this procedure may be categorized into the immediate and the long term. Since the fever or diarrhea symptoms of the infant do not get the appropriate treatment, there is the likelihood of the pre-existing illness to worsen. Additionally, the non-sterile invasive method used to gouge the tooth out may result in bleeding and infection. These may be so severe to cause anemia, septicemia, osteomyelitis, or meningitis (8, 20–23). A study of hospital admissions in Northern Uganda observed that children who had undergone IOM were among the 10 most common hospital admissions and had the third highest case fatality rate (CFR = 21%) (24).

The long-term impacts are observed especially in the dentition and include malformation, non-eruption, hypoplasia, dysplasia, missing teeth, displacement and impaction, compound odontoma, and orthodontic complications (7, 11, 17, 21). The teeth most commonly affected are the mandibular canines. A study of 14-year olds in the city of Kampala found that in the mandible, missing canines were as common as missing first molars. The occurrence of missing canines could be explained as result of IOM and had impact on the children occlusal status (25).

ATTITUDES OF UGANDA POPULATIONS TO IOM

In Uganda, IOM is carried out commonly by traditional healers, though other respected members of the community may conduct the procedure. The literature mentions family members, traditional midwives, school teachers, and even local priests conducting IOM (5, 20, 22). Traditional healers remain widespread in Uganda as with most of Africa, especially in the rural areas where the populations rely greatly on their services. In a study of traditional healers, 40% had no formal education, whereas 46.6% had only primary school education (26). Traditional healers take up their role as a cultural heritage. Ellis and Arubaku (23) state that families initially consult a traditional healer before hospital, and even while at hospital may continue the dialog. In the National Oral Health Plan, when participants were asked about *Ebinyo*, more than 50% stated that the best treatment is by a traditional healer (19). A later study conducted in a Kampala clinic in 2007, guardians reported traditional healers were responsible for 55%

of IOM observed (*MW*). The authors conclude that this reflected the poor health literacy of the studied Uganda population. In a study by Nuwaha et al. (27) in a western part of Uganda, it is reported that socioeconomic conditions do not influence IOM as a preferred choice of treatment. In neighboring Tanzania, IOM was outlawed in 1980s, but as of 1990s, it was still occurring in areas that have poor access to health services (28). Therefore, IOM persistence and spread may be due to poor health literacy and limited access to health services in these populations.

This continued inhumane practice of IOM is conducted at an age where the antibodies protection passed on to a child during pregnancy and from breast milk is decreasing. The child, thus, becomes susceptible to various infections. These infections present with symptoms of fevers, diarrhea, and vomiting that IOM is performed to treat. Notably, a high proportion of morbidity and mortality in under 5-year olds in Sub-Saharan Africa is from these infections (27, 29). The prevailing mismanagement of the infections, such as IOM in the Uganda population, thus presents as a contributory factor to the health burden of children (2).

CONCLUSION

Infant oral mutilation should be eradicated. The interventions ought to involve traditional healers and offer improved access to primary health care, especially in rural areas. The majority of the studies in literature focus on the dental impacts of IOM with minimal reporting on the reasons for delay seeking proper care from conventional health services. Health professionals in particular pediatricians should be informed and liaise with dental practitioners to develop strategies to eliminate this practice. Further research into the conditions that are promoting such beliefs should be explored.

AUTHOR CONTRIBUTIONS

MW and BK contributed to the concept of the manuscript. Furthermore, they worked together to develop the design and select the content. Both authors agreed to the final version and approved it ready for submission.

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Racial Disparities in Emergency Department Utilization for Dental/Oral Health-Related Conditions in Maryland

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Objectives: Hospital emergency departments (EDs) are a place where many Americans seek treatment of dental conditions. Racial and ethnic minorities consistently have higher rates of ED utilization than whites for dental conditions. The reasons for these disparities and significant public health concerns are investigated less often. In this paper, we measure trends in racial disparities in ED discharges for dental conditions in Maryland from 2010 to 2013. To understand these disparities, we also describe differences between racial groups in age, gender, income, location, payer, comorbidities, and the availability of dental care.

Methods: 2010–2013 State Emergency Department Data for Maryland were used in the analysis. Rates per 100,000 of the population are calculated using information from census population estimates. Cost-to-charge ratios are used to estimate the costs of ED discharges. Dental/oral health-related conditions (DOHRC) are defined as discharge diagnoses of ICD-9-CM codes 520.0 through 529.9. Descriptive statistics and fixed effects logistic regression models with a rare event correction are used to analyze the data.

Results: Blacks, especially females aged 25–34, have larger proportions of total ED discharges due to DOHRC, and higher population rates of DOHRC, than any other racial or ethnic group. In 2013, Blacks represented 30% of Maryland's population and accounted for 52% of ED costs for DOHRC. Hispanics and those of other races have much lower rates of DOHRC discharges. The regression results show that the high proportion of DOHRC discharges among Blacks may be explained by the concentration of Blacks in low-income central cities with less access to dental care.

Conclusion: There are significant racial disparities in the ED utilization for DOHRC in Maryland. These disparities reflect the lack of access to dental care due to both cost and geographic limitations. This results in high healthcare costs and ineffective solutions for patients. Addressing oral health disparities will require policy solutions that are targeted to the populations most at need, and action plans that combine community and state level efforts.

Keywords: oral health, emergency service, hospital, healthcare disparities, cost of care, Maryland

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INTRODUCTION

Americans increasingly utilize hospital emergency departments (EDs) for the treatment of dental conditions (1, 2). These visits are primarily palliative and underlying problems are rarely satisfactorily treated potentially resulting in further pain, worsening oral health, and additional cost for patients and families (3). These visits are frequently caused by a lack of access to affordable dental care (4–6).

Racial disparities in the utilization of EDs for dental conditions are a consistent finding in research about this public health concern. Evidence from Wisconsin, New Jersey, and Maryland demonstrates that Black Americans, especially those with no or public insurance and of low socioeconomic status, have higher rates of ED visits than whites (7–10). The most commonly cited reasons for these high rates include poor overall and oral health combined with a lack of access to dental insurance and care (7–9, 11–13). However, little explanatory work has been done in this area. Evidence regarding other racial groups is much more limited. Some evidence suggests that Hispanics have higher rates of ED visits for dental conditions due to a lack of access to dental care and lower average health literacy (14). However, there is a well-known "Hispanic Paradox" in which Hispanics have better overall and oral health than might be expected, given their average socioeconomic status (11, 15).

In this paper, we assess racial disparities in ED discharges for dental conditions in Maryland from 2010–2013. We chose to focus on Maryland for several reasons. First, recent public and policy attention in Maryland has been focused on reducing disparities in access to oral health care (16). Second, ED discharges for dental conditions in Maryland are well understood and mirror national trends (9, 14, 17). As occurs nationally, EDs in Maryland are not capable of providing definitive treatment of dental conditions. Therefore, many patients either see a dentist to complete treatment or return to the ED for further palliative care and their condition is left unresolved (9, 17). The demographics of Maryland are somewhat different from national averages. In particular, Maryland is more racially diverse, has higher average income, and is slightly more urban than national averages (18). Finally, despite the wealth of research and programs in Maryland, there has been no comprehensive research documenting differences in ED discharges for dental conditions across racial groups.

MATERIALS AND METHODS

Data

The data used in this paper come from the 2010 to 2013 State Emergency Department Databases (SEDD) of the Healthcare Cost and Utilization Project (HCUP) for Maryland. A dataset that pooled discharges from the 2010 through 2013 datasets was created to facilitate comparisons over time. These data and analysis are representative of the total population of ED discharges over this period. When reported, rates per 100,000 of the population were calculated using information from county level population estimates (18). Information on the number of dentists and ratio of dentists to population comes from the Area Resources Health Files (19). Cost-to-charge ratios from HCUPs were used to estimate the costs of ED discharges (20). These ratios reflect inpatient costs but have been used in prior research on ED discharges (2) and are the best available tool for estimating the actual costs of ED visits.

Variables

Dental/oral health-related conditions (DOHRC) are defined as diagnoses of ICD-9-CM codes 520.0 through 529.9. Variables indicating preventability and severity of DOHRC were created using a schema that classifies ICD-9-CM dental diagnosis codes based on the severity of the condition and the likelihood that the conditions were preventable through normal dental care (21). In order to ensure an adequate sample size to analyze differences between racial groups, we collapsed race into four categories: Whites, Blacks, Hispanics, and other races. Comorbidities are defined using the expanded Elixhauser comorbidities index (22). Other variables in this analysis include age, gender, income, location, payer, and the availability of dental care.

Methods

When conducting descriptive analysis, Chi-square tests are used to determine if there are differences between expected and observed distributions of the independent variables and the dependent variables. The statistical significance of individual cells of data is determined by the contribution of that cell to the overall Chi-square using a p value cutoff of <0.05. Results of these descriptive statistical tests are presented in Appendix S1 in Supplementary Material.

A fixed effects logistic regression model that contrasts DOHRC discharges with other discharges is estimated. These models "fix" or control for the effect of time, producing estimates that show year over year averages. The relatively rare nature of DOHRC discharges in the full sample necessitates the use of a rare event correction to ensure accurate predictions. The rare event correction is performed by randomly selecting a 5% subsample of non-DOHRC discharges to create a balanced sample and then a correction for the resulting sample selection bias (23).

Two models are estimated. The first estimates the effect of race on the odds of being discharged with a DOHRC relative to any other condition. The second model adds variables that may mediate the relationship between race and odds of having a DOHRC discharge, as identified by the descriptive analysis. These variables include a gender by age interaction, the rate of dentist per 100,000 of population in the county, location of residence, and median household income in the county of residence.

RESULTS

Dental/oral health-related conditions discharges are not evenly distributed by race (**Table 1**). For all years, between 3.0 and 3.1% of all ED discharges among Blacks are due to DOHRC, the highest among racial groups and higher than the population average of 2.7–2.8%. In comparison, only 1.3–1.5% of ED discharges among Hispanics and those of other races are due to DOHRC

TABLE 1 | Maryland emergency department (ED) discharges for dental/oral health-related conditions (DOHRC) by race using 2010–2013 State Emergency Department Data (SEDD).

	Count of DOHRC	Rate per 100,000 of population	%	% of total ED discharges	Average cost ($)	Total cost ($)	Count of DOHRC	Rate per 100,000 of population	%	% of total ED discharges	Average cost ($)	Total cost ($)
	2010						2011					
White	26,641	841.27	48	2.8	222	5,246,897	27,276	861.04	47	2.7%	248	5,614,868
Black	26,475 ↑	1,570.50	48	3.0	255	6,041,558	27,628 ↑	1,621.94	48	3.0%	279	6,668,503
Hispanic	1,134 ↓	238.57	2	1.4	263	266,266	1,187 ↓	239.50	2	1.3%	263	277,131
Other	1,315 ↓	285.72	2	1.5	247	283,132	1,368 ↓	286.78	2	1.5%	303	344,071
Total	55,565	959.99		2.8	239.05	11,837,853	57,459	983.24		2.7%	264.53	12,904,573
	2012						2013					
White	26,648 ↓	841.68	45	2.6	280	6,269,330	23,166 ↓	733.14	43	2.5	338	6,709,003
Black	29,973 ↑	1,745.11	50	3.0	317	8,345,708	27,793 ↑	1,602.58	52	3.1	342	8,259,798
Hispanic	1,563 ↓	303.50	3	1.5	277	376,909	1,452 ↓	271.24	3	1.3	302	365,831
Other	1,604 ↓	325.21	3	1.4	334	433,411	1,450 ↓	284.68	3	1.4	333	399,606
Total	59,788	1,014.76		2.7	300.38	15,425,358	53,861	906.94		2.7	333.98	15,734,238

↑ indicates Chi-square significantly higher than expected and ↓ indicates significantly lower than expected. DOHRC are defined as diagnoses of ICD-9-CM codes 520.0 through 529.9. Estimates from Maryland SEDD, 2013, Agency for Healthcare Research and Quality (AHRQ). Costs calculated using cost-to-charge ratio files for the state inpatient databases, 2013, AHRQ.

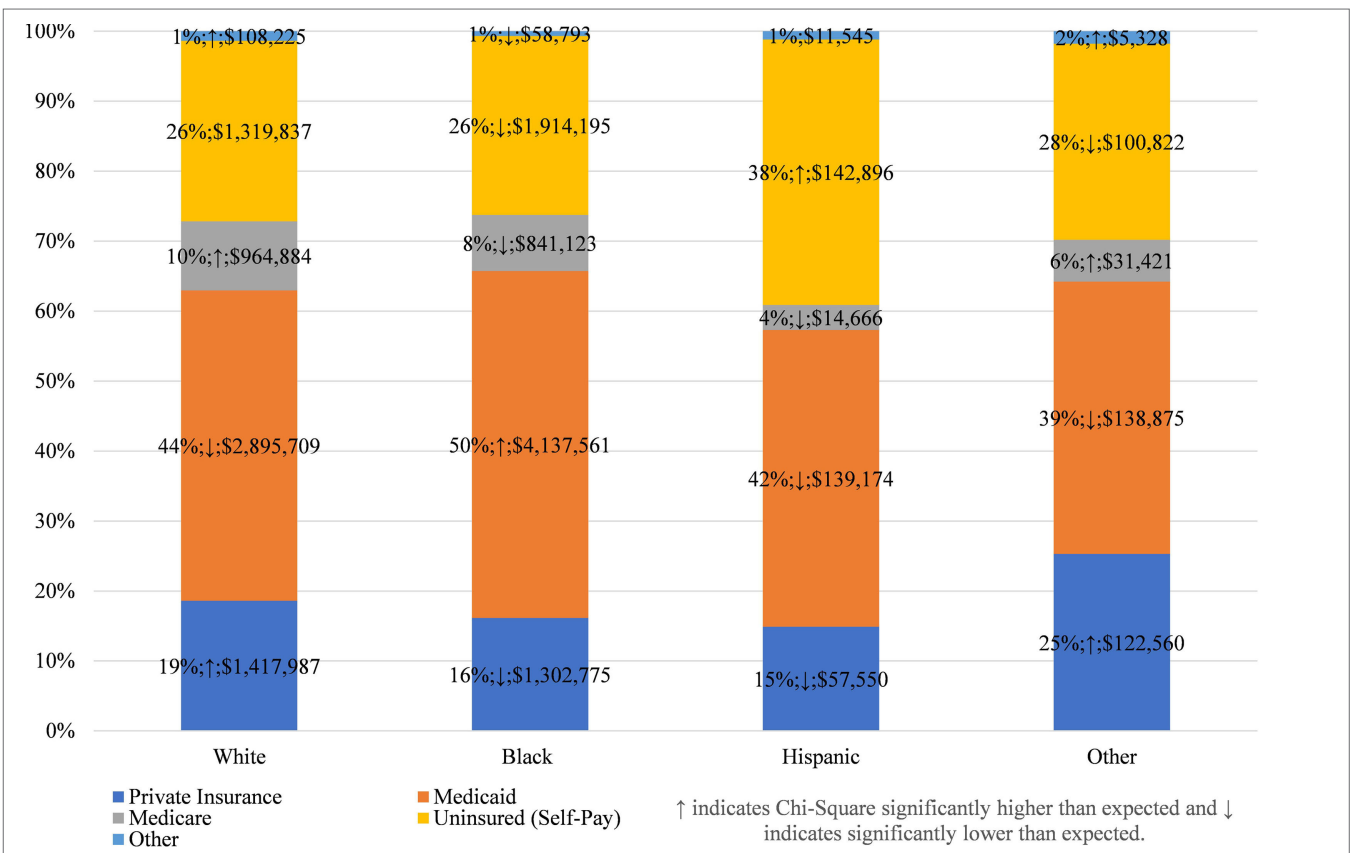

FIGURE 1 | Expected payers of dental/oral health related conditions discharges, by race, in Maryland 2013.

(see Appendix S2 in Supplementary Material for information on all ED discharges). Across all years, Blacks also have by far the highest population rates of DOHRC discharges and the proportion of DOHRC discharges among this racial group increases from 48% in 2010 to 52% by 2013. Whites have the next highest population rate of DOHRC discharges, but those rates decline from 2010 to 2013. Hispanics and those of other races have low, but increasing, rates of DOHRC.

This concentration of inappropriate and ineffective ED treatment among a single racial group has implications beyond the disservice to the patients involved. In total, $15.7 million was spent in Maryland in 2013 treating dental conditions in the ED, an increase of $4 million from 2010, adjusted for inflation (**Table 1**). On average, 51% of the total cost was spent on DOHRC discharges among Blacks, who represent about 30% of Maryland's population. Moreover, because half of all Blacks discharged for DOHRC are enrolled in Medicaid in 2013, these discharges place a burden on taxpayers (**Figure 1**).

This payer mix is not, however, unique to Blacks. Among all racial groups, Medicaid is the largest payer of costs for ED DOHRC; followed by the uninsured themselves (**Figure 1**; see Appendix S3 in Supplementary Material for all years). Private insurance is more likely to pay for DOHRC discharges among Whites and other races than expected, while the Hispanic DOHRC patients are more likely to be uninsured.

Among all racial groups, females and those aged 25–34 have the highest rates of discharges for DOHRC (**Figure 2** for 2013; Appendix S4 in Supplementary Material for all years). Within each gender and age category, Blacks consistently have the highest rates, while Hispanics and other races have the lowest rates. Black females aged 25–34 have a rate of 4,218 per 100,000, while Black males have a rate of 3,746. No other rate across the race, gender, and age distribution exceeds 2,500. Also of note is that rates for Whites and Blacks follow a much more pronounced distribution, with large peaks at 25–35, whereas those for Hispanics and other races are more evenly distributed across the age distribution.

To understand why these racial disparities in DOHRC discharges exist, we separate median household income of the zip code (**Figure 3**) and the location of residence (**Figure 4**) of the discharged patients by race. Blacks discharged with a DOHRC are disproportionately more likely to live in zip codes in the bottom income quartile. Across all years, about 35% of all Blacks discharged with a DOHRC live in zip codes where the median household income is less than $39,000 per year (**Figure 3**). In comparison, 16% or less of the other racial groups discharged with any condition live in low-income zip codes and the percentages for those groups decline over time. Hispanics and those of other races are the least likely to live in poor zip codes. Those discharged with a DOHRC, regardless of racial group, are more likely to live in zip codes with a median household income in the bottom quartile compared to those discharged with a medical condition (Appendix S5 in Supplementary Material). For example, 27% of Blacks discharged with a medical condition live in poor zip codes in 2013, compared to the 34% discharged with a DOHRC. Blacks discharged with a DOHRC are also more likely to live in a large central metro area (43%, **Figure 4**), relative to Blacks discharged with a medical condition

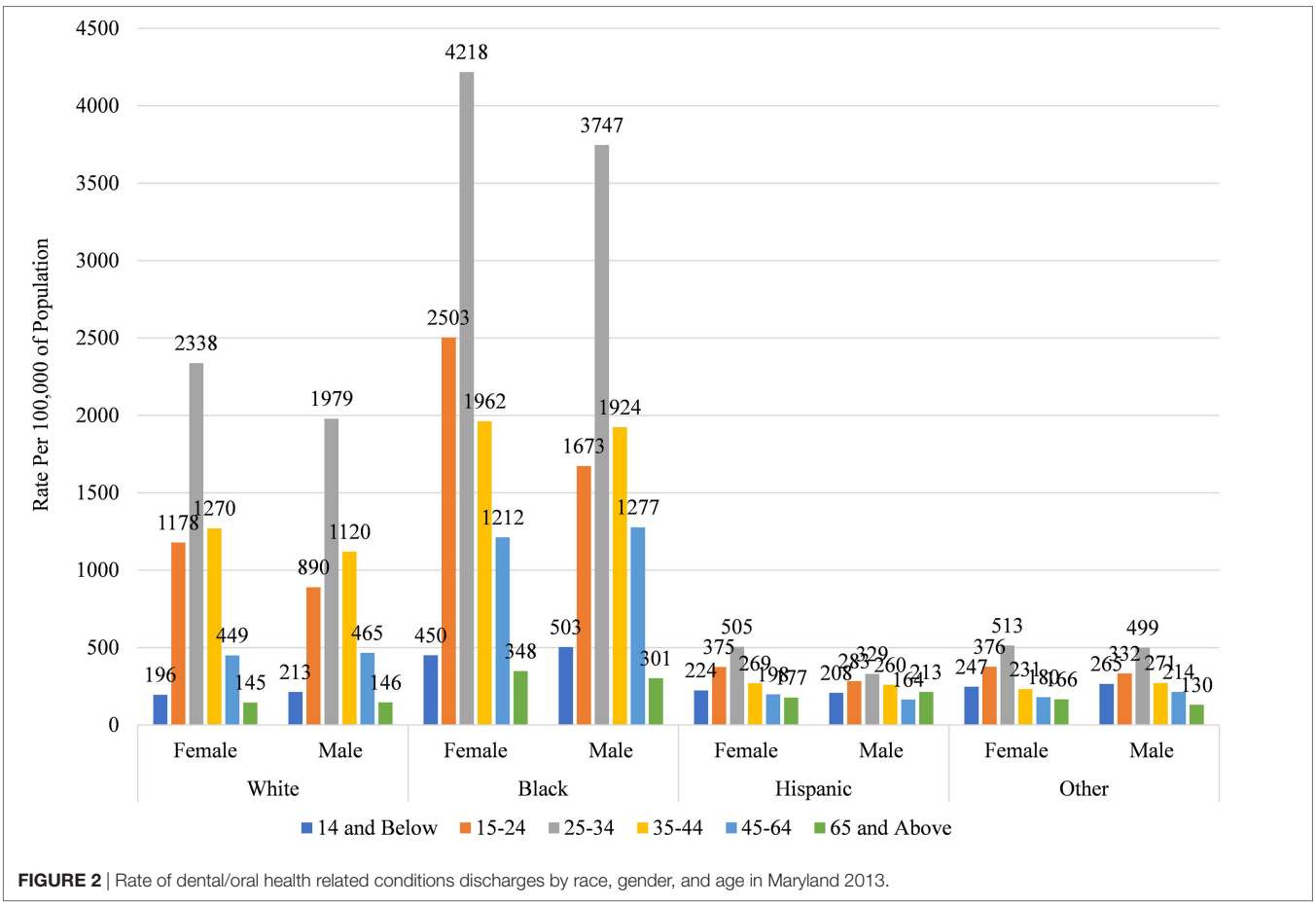

FIGURE 2 | Rate of dental/oral health related conditions discharges by race, gender, and age in Maryland 2013.

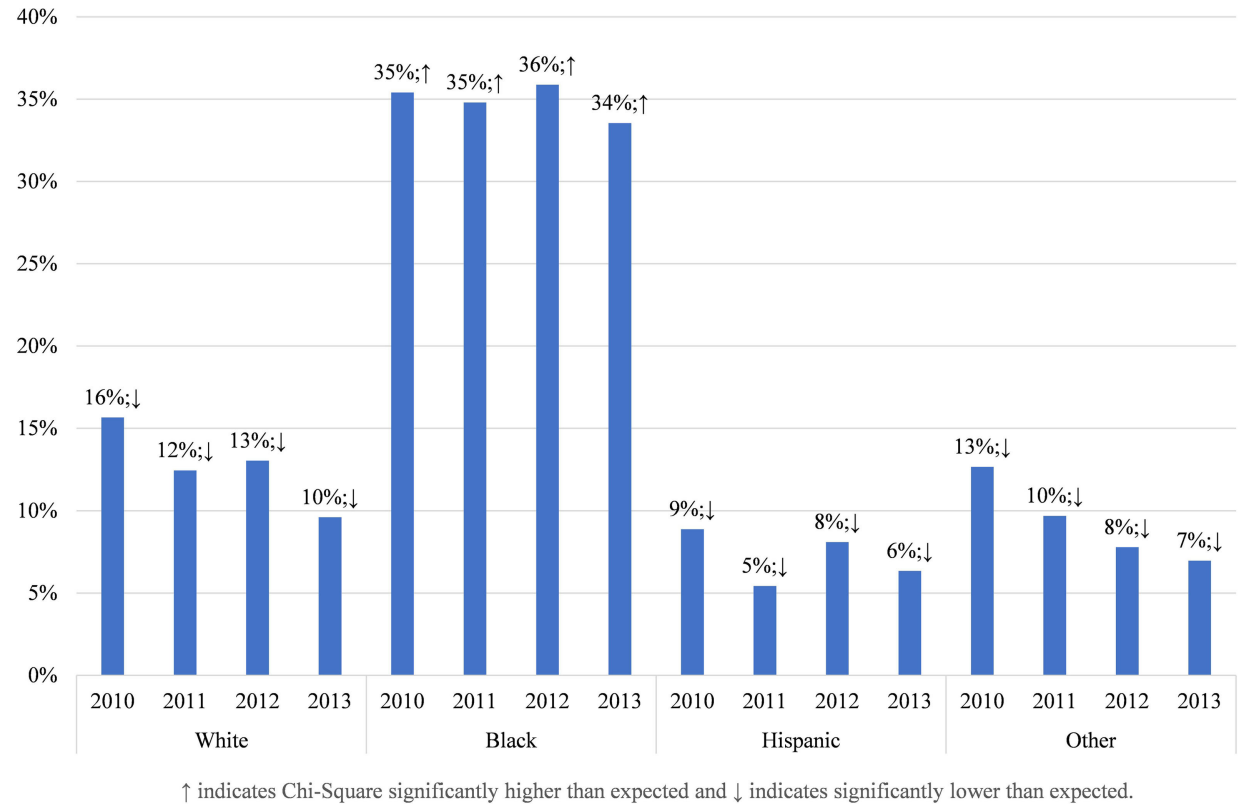

FIGURE 3 | Proportion living in zip codes with median household incomes in bottom quartile, by race, in Maryland 2013.

(36%, Appendix S6 in Supplementary Material) or others. Two-thirds or more of Whites, Hispanics, and other races discharged with any condition live in the generally wealthier suburbs.

This concentration of Blacks into low income, central city areas in Maryland is significant because Blacks are more likely to live in areas that have relatively few dentists per capita (**Figure 5**) and more than half live in counties that are below the median rate for dentists in the population (**Figure 6**). This finding is consistent with prior research that those living in low-income areas and those with low incomes are more likely to report that their mouth and teeth are in poor condition (24). It is also consistent with prior research that those living in low-income areas and those with low incomes are more likely to delay going to the dentist due to costs or difficulty finding a dentist (13, 24). Thus, Blacks may go the ED for dental care because they do not have access to the dentists, either because of geographic restriction or because of cost; and because EDs are relatively accessible and will treat patients with emergent conditions regardless of ability to pay. Comparatively, Hispanics and those of other races live in counties with more dentists per population (**Figure 5**) and less than half live in counties below the median rate of dentists (**Figure 6**). Thus, the low rate of ED discharges for these racial groups may be due to better access to dental care for these populations.

Racial disparities in ED discharges for DOHRC do not appear to be associated with differences in comorbidities (Appendix S7 in Supplementary Material). Regardless of race and ethnicity, those discharged with a DOHRC are less likely to have a chronic comorbidity that would complicate treatment than those discharged with a medical condition, with 22% or less having one or more. In addition, there are no differences in the preventability or the severity of dental conditions that are diagnosed in the ED that would explain the differences in rates seen across racial groups (Appendix S8 in Supplementary Material).

To test our hypothesis that disparities in ED discharges by race are due to residential segregation into high- and low-income areas with differential access to dentists, we estimate two fixed effects logistic regression models that estimate the odds of being discharged with a DOHRC relative to any other condition (**Table 2**). The first model, which includes only race, is reflective of the descriptive findings, Blacks are 20% more likely than Whites to be discharged with a DOHRC, relative to being discharged for a medical condition. On the other hand, Hispanics and those of other races are 40% less likely than Whites to be discharged for a DOHRC.

The second model in **Table 2** adds variables that may mediate the relationship between race and odds of having a DOHRC discharge, as identified by the descriptive analysis. These variables include a gender by age interaction, the rate of dentist per 100,000 of population in the county, location of residence, and median household income of the county of residence. Those who live in counties with a greater density of dentists are less likely to visit the ED for a DOHRC. Those who live in a large

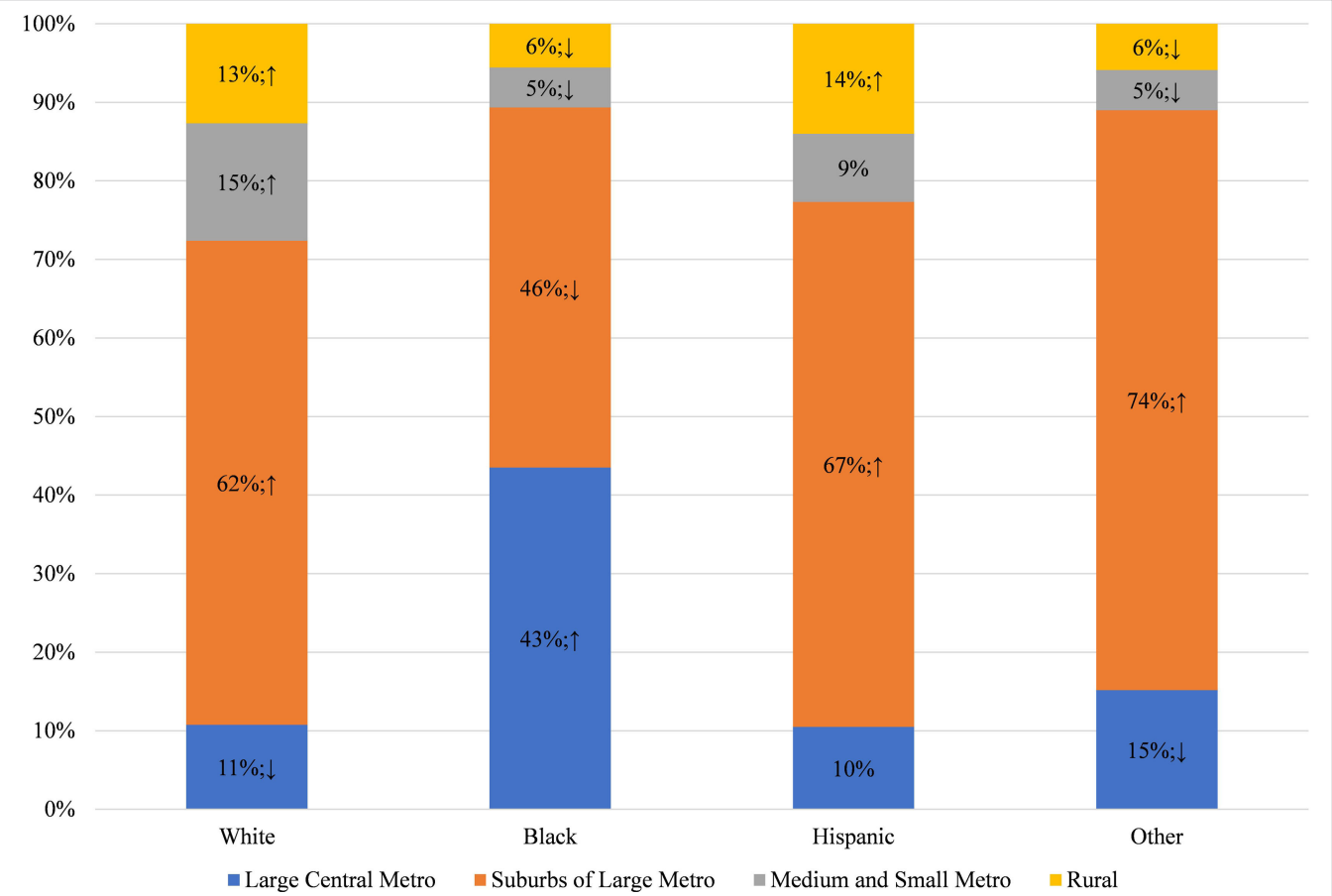

FIGURE 4 | Location of residence of dental/oral health related conditions discharges, by race, in Maryland 2013.

central metro are more likely and those with high incomes are less likely to visit the ED for DOHRC, relative to visiting for a medical reason. Finally, there is a significant gender by age interaction, although once the other variables are accounted for, males are slightly more likely than females to visit the ED for a DOHRC.

When these variables are added to the model, the variable for Blacks becomes non-significant. This indicates that the difference between Blacks and Whites in the proportion of ED discharges that are due to DOHRC is caused by the relative disadvantage of Blacks in terms of income, location, and access to dental care. On the other hand, the variables for Hispanics and those of other races continue to be significant and with no or small reductions in magnitude. Therefore, the lower proportion of DOHRC for these groups is not associated with their relatively privileged position on the variables in the model.

DISCUSSION

In this paper, we identified significant racial disparities in ED discharges for DOHRC in Maryland between 2010 and 2013, with Blacks having a larger proportion of total ED discharges and higher population rates than any other group. Black females between the ages of 25–34 have by far the highest rates in the population. This disparity is not strongly related to worse overall health or different patterns of diagnoses in this population. Instead, as established in our regression models, it is associated with a lack of access to dental care due to cost and availability because of a concentration of this population in low-income and central city areas. Our findings are consistent with previous research that a higher level of ED utilization for dental conditions among Blacks is due to a lack of access to dental care. Our findings also support research documenting the better overall and oral health of Hispanics (11, 15), which in our analysis, cannot be explained by differences in access to dental care.

While the analysis presented here provides systematic evidence of racial disparities in ED utilization for dental conditions, there are obvious limitations. Because administrative data are used in the analysis, there is relatively little information on the patient themselves. Better information on the patient overall oral health status, dental insurance coverage, and their values related to oral health would provide more complete explanations of the reason and solutions for these racial disparities.

The ED is not the place for treatment of dental conditions for anyone. Costs are high and the care provided is palliative at best. The disproportionately high level of DOHRC discharges for

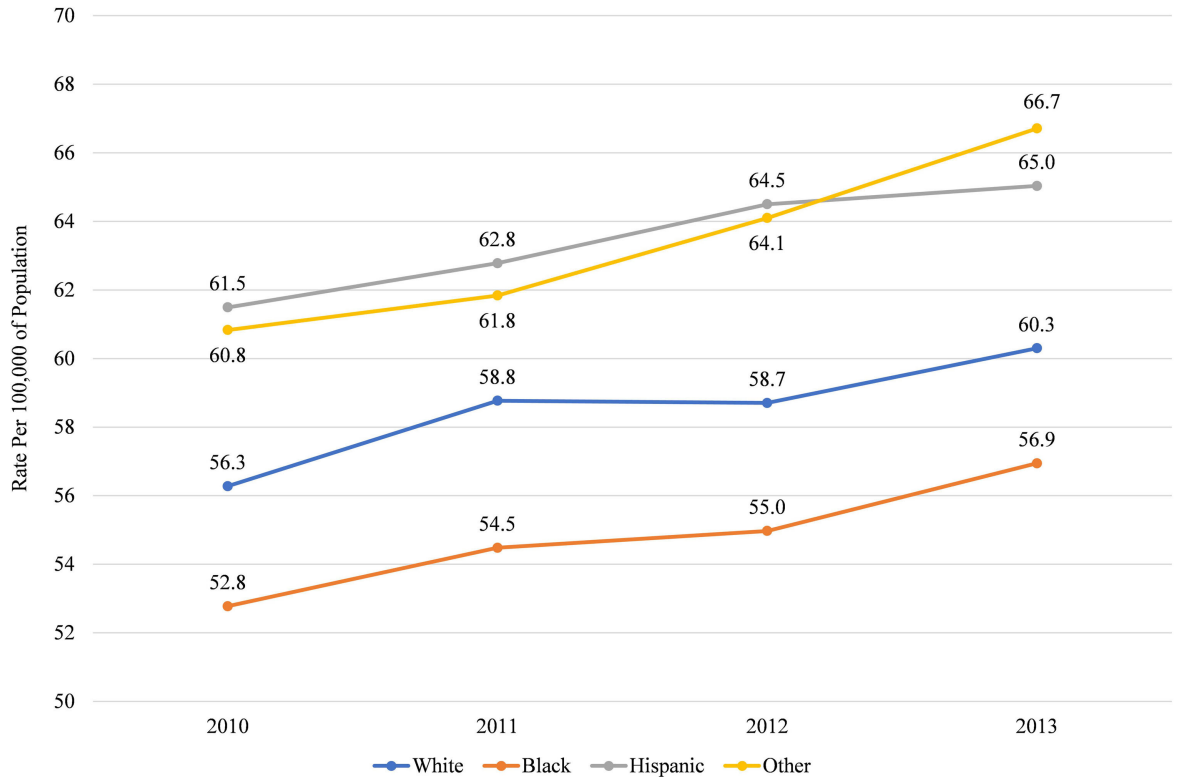

FIGURE 5 | Median rate of dentists per 100,000 of population in county, by race, in Maryland 2010–2013.

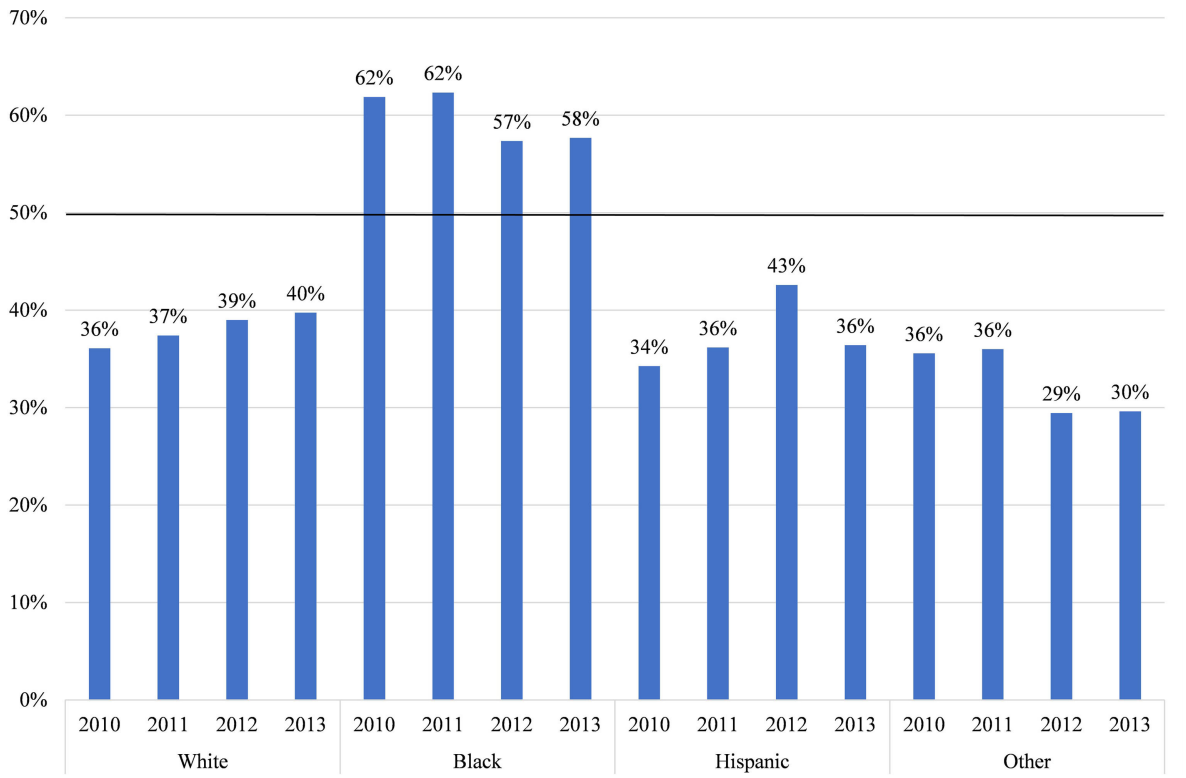

FIGURE 6 | Proportion living in counties with below median rate of dentists per 100,000, by race, in Maryland 2010–2013.

TABLE 2 | Fixed effects logistic regression model estimating dental/oral health-related condition (DOHRC) discharges in Maryland using State Emergency Department Data (SEDD) 2010–2013.

	Model 1: race only			Model 2: race + potential mediators		
	DOHRC discharge (reference: all other discharges)			DOHRC discharge (reference: all other discharges)		
Independent variable	**Odds ratio**	**SE**	**Pred. prob. of a DOHRC Diag.**	**Odds ratio**	**SE**	**Pred. prob. of a DOHRC diag.**
Race						
(Reference: white)	–	–	0.25	–	–	0.27
Black	1.206*	0.006	0.29	1.002	0.006	0.27
Hispanic	0.600*	0.009	0.17	0.594*	0.010	0.18
Other race	0.594*	0.009	0.17	0.679*	0.011	0.20
Gender × age interaction						
(Reference: males 14 and below)	–	–	–	–	–	0.12
Males 15–24	–	–	–	3.504*	0.055	0.32
Males 25–34	–	–	–	6.036*	0.089	0.45
Males 35–44	–	–	–	3.731*	0.059	0.34
Males 45–64	–	–	–	2.151*	0.033	0.23
Males 65 and above	–	–	–	0.666*	0.017	0.08
Females 14 and below	–	–	–	1.102*	0.020	0.13
Females 15–24	–	–	–	0.846*	0.019	0.31
Females 25–34	–	–	–	0.725*	0.015	0.39
Females 35–44	–	–	–	0.721*	0.016	0.29
Females 45–64	–	–	–	0.762*	0.017	0.20
Females 65 and above	–	–	–	0.783*	0.027	0.07
Rates dentists per county population	–	–	–	0.997*	0.000	–
Location						
(Reference: large central metro)	–	–	–	–	–	0.27
Suburbs of large metro	–	–	–	0.965*	0.009	0.27
Medium and small metro	–	–	–	0.816*	0.010	0.24
Rural	–	–	–	0.871*	0.011	0.25
Household income quartile						
(Reference: $64,000+)	–	–	–	–	–	0.31
Less than $39,000 per year	–	–	–	1.690*	0.018	0.31
$39,000–$47,999 per year	–	–	–	1.634*	0.016	0.27
$48,000–$63,999 per year	–	–	–	1.331*	0.009	0.22
Year						
(Reference: 2013)	–	–	0.26	–	–	0.27
2010	1.077	0.008	0.27	0.996	0.008	0.26
2011	1.008	0.007	0.26	0.949*	0.007	0.26
2012	1.015	0.007	0.26	0.968*	0.007	0.27
Constant	0.327*	0.002	0.26	0.137*	0.003	0.26
Number of observations	869,741			869,741		
Model Chi-square test	5,153.62*	(6 *df*)		68,264.95*	(24 *df*)	
Goodness of fit Chi-square test	137.10*	(9 *df*)		22,812.52*	(9,492 *df*)	
Observations correctly classified	73.94%			73.8%		

*$p < 0.001$.

DOHRC are defined as diagnoses of ICD-9-CM codes 520.0 through 529.9. Estimates from Maryland SEDD, 2010 through 2013, Agency for Healthcare Research and Quality (AHRQ). Rare event correction used, which uses the full sample of DOHRC discharges and a 5% random subsample of all other discharges.

Blacks in Maryland create high costs for Medicaid and ineffective solutions for patients. The disparities revealed in this paper highlight the importance of solutions targeted to the populations most at need. Any solution is going to need to combine community and government action to deal with lack of access to dental care due to location and cost. The proposed restoration of an adult dental care benefit for Maryland residents would allow Medicaid beneficiaries to seek dental care in more appropriate, and cost effective, settings (25, 26). Promising community interventions to divert patients from the ED to dentists that can deliver acute dental care have been successfully used to reduce ED visits for dental conditions in rural Maryland (27).

AUTHOR CONTRIBUTIONS

NC developed the concept and design of the study; NC contributed to the acquisition of data, analysis, and interpretation of data; NC made contribution to drafting and revising the article and the final approval of the version to be submitted.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at http://journal.frontiersin.org/article/10.3389/fpubh.2017.00164/full#supplementary-material.

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Comparison of Orthodontic Medicaid Funding in the United States 2006 to 2015

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Introduction: Orthodontic treatment is reimbursed by Medicaid based on orthodontic and financial need with qualifiers determined by individual states. Changes in Medicaid-funded orthodontic treatment following the "Great Recession" in 2007 and the enactment of the Affordable Care Act in 2010 were compared for the 50 United States and the District of Columbia to better understand disparities in access to care. The results from this 2015 survey were compared to data gathered in 2006 (1).

Materials and methods: Medicaid officials were contacted by email, telephone, or postal mail regarding the age limit for treatment, practitioner type who can determine eligibility and provide treatment, records required for case review, and rate and frequency of reimbursement. When not attained by direct contact, the information was gleaned from online websites, provider manuals, and state orthodontists.

Results: Information gathered from 50 states and the District of Columbia documents that Medicaid program characteristics and expenditures continue to vary by state. Expenditures and reimbursement rates have decreased since 2006 and vary widely by geographic region. Some states have tightened restrictions on qualifiers and increased submission requirements by providers.

Conclusion: The variation and lack of uniformity that still exists among Medicaid orthodontic programs in different states creates disparities in orthodontic care for US citizens. Barriers to care for Medicaid-funded orthodontic treatment have increased since 2006.

Keywords: medicaid database, orthodontic services, Medicaid dental expenditures, state expenditures, Medicaid funding, Medicaid reimbursement, Medicaid eligibility, affordable care act

INTRODUCTION

Medicaid funding for orthodontic services is a multifaceted issue with programmatic variation among states that can influence where orthodontists practice and who and how they treat. The Social Security Act was signed by President Lyndon Johnson in 1965. Title XIX of the Act, commonly known as Medicaid 1965 (2), was developed to provide healthcare coverage to the medically indigent. Title XIX listed certain medical services that states could fund with federal sharing.

Orthodontics, although not specifically listed, was included with dental care (2). The Early and Periodic Screening, Diagnosis, and Treatment Program (EPSDT), established in 1967, is a component of Medicaid that provides preventive services and treatment for children and mandates access to orthodontic treatment for Medicaid eligible patients (3). *Handicapping malocclusions* were deemed eligible for Medicaid funding. With Medicaid financed half by the federal government and half by state government, it is at the discretion of individual states to define the term *handicapping malocclusion*. Consequently, there is wide disparity throughout the United States regarding Medicaid coverage of orthodontic treatment. There is a federal ceiling on income eligibility to limit expansion of the program beyond its original scope.

When Medicaid began in 1965, the American Dental Association (ADA) worked collaboratively with federal organizations to help define covered procedures and favored a national dental health program for children. A task force convened in 1966 recommended "treatment of malocclusion with priority provided for interceptive service and disfiguring or handicapping malocclusions" (2). Interceptive orthodontics, sometimes referred to as early orthodontics or Phase I treatment, has been shown to significantly reduce malocclusion severity in a comparison of Medicaid and private-pay populations (4). Improvements resulting from Phase I treatment can recategorize patients from the medically necessary category to the elective category, requiring less time and cost to treat (5, 6). However, such early orthodontic treatment may also improve a patients' malocclusion enough to no longer have a *handicapping malocclusion* and thus be disqualified from receiving definitive orthodontic care. Consequently, the provision of Phase I treatment can present a conundrum regarding qualification for funding.

The American Association of Orthodontists (AAO) has defined medically necessary orthodontic care as "the treatment of a malocclusion (including craniofacial abnormalities/anomalies) that compromises the patient's physical, emotional or dental health." (7) The AAO originally selected the Salzmann index (8) as an objective qualifier for treatment funding for *handicapping malocclusions*. However, this decision was rescinded in 1985, with the AAO opposing the use of any index or classification system to determine orthodontic treatment need (9).

Since state budgets require funding decisions, most states still use an index as a qualifying criterion to define a *handicapping malocclusion*. Various malocclusion indices, sometimes with modifications, are used by states to serve their populations while meeting budget needs. With no standardization for determining qualified cases, disparity exists in orthodontic Medicaid case approvals. Moreover, states continue to alter criteria for funded care; the state of Iowa, for example, recently increased the case complexity required for approval, thus decreasing the number of cases funded per budget year (10). This raises the concern that patients in need are being disqualified from receiving treatment due to tightened state budgets.

Esthetic components of a malocclusion may or may not be considered by reviewers when determining cases to approve for funding. Some states use indices that include an esthetic component in addition to the study cast analysis. Examples of these indices are the Index of Complexity, Outcome and Need (11), Salzmann Index (8), Dental Aesthetic Index (12), and the Index of Treatment Need (13). Some states use indices that lack an esthetic component and rely purely on study cast analysis. These include the Handicapping Labiolingual Deviation (HLD) Index (14), Peer Assessment Rating Index (15), and the HLD (CalMod) Index (16). Use of study cast analysis only to determine treatment need may not give a clear picture of an existing visual deformity. Cast analysis alone frequently indicates that there is no need for orthodontic treatment; however, a visual assessment would have a different outcome.

Despite the EPSDT and Medicaid initiatives, which predicate federally required coverage, there are income, racial, ethnic, cultural, and geographic barriers limiting access to specialty dental care, including orthodontics. These and other barriers vary the rate of orthodontic care utilization by publicly insured children and adolescents. Disparities exist in the availability of orthodontic care for private versus publically insured youth in the United States (10, 17, 18). State to state variability in US orthodontic Medicaid programs also contributes to nation-wide geographical disparities.

Receiving state approval for funding of orthodontic treatment does not guarantee receipt of orthodontic care if an accessible care provider is not available. Medicaid reimbursement fees are substantially less than the usual and customary fees charged by dentists and orthodontists. Private practice office overhead has continued to increase since 2006. However, Medicaid reimbursement rates have decreased; in some states, the decrease is significant. In addition to lower reimbursement rates, Medicaid providers may have to hire additional staff to process the state required paperwork, submit required records, and follow-up on payments, thus increasing the office overhead. Consequently, some providers either choose not to accept Medicaid patients or severely restrict the number of Medicaid patients in their practice. As a result, individuals either go without care or are forced to travel, sometimes long distances, to obtain treatment.

To examine and compare the effects on Medicaid-funded orthodontic treatment that have occurred since the "Great Recession" starting in 2007 and the enactment of the Affordable Care Act (ACA) in 2010, a comparative study was designed to parallel the previously published study "Medicaid Expenditures for Orthodontic Services" (1).

MATERIALS AND METHODS

The methods and categories used in the 2006 study were repeated for comparison purposes. PubMed, Ovid, Google, Medicaid websites, and the state Medicaid Dental Services Section were accessed to identify the appropriate contact person for each of the 50 United States and District of Columbia. In addition, as much information as possible was gathered from state Medicaid websites. The identified person for each state was contacted by email and/or phone and secondarily by postal mail. For states where this person could not be ascertained or accessed, the information was acquired from that state's general (non-dental) Medicaid office and orthodontist Medicaid providers. An introductory letter was sent by postal mail or email describing the 13-question multiple-choice survey, which,

when necessary, was administered by phone. Data were analyzed with descriptive statistics and frequency distributions. Select tables replicate categories used in the 2006 study.

Although various forces in the external environment changed between 2006 and 2015, this study was a preliminary analysis to examine if these changes impacted Medicaid-funded orthodontic treatment. The study was not intended to analyze causation.

RESULTS

Email or postal mail responses were received by 43 states and the District of Columbia. For the remaining seven states (AZ, MA, RI, SC, SD, TN, and TX), as much information as possible was gathered from online websites, provider manuals, and published fee schedules. Patient websites were available for 33 states, and provider websites were available for 46 states. All states indicated provision of some services under Medicaid except for Michigan where orthodontic coverage is *via* another program for special needs beneficiaries with particular medical diagnoses such as cleft palate. This program is not under the auspices of Medicaid and utilizes a different funding source. Provider reimbursement rates for Michigan's dental care program were included for comparison; however, since not participating specifically in Medicaid, other Michigan data were not included.

Eligible Providers

In 2015, 48 states specified the type of dentist eligible to provide Medicaid-funded orthodontic care. A general dentist, orthodontist, or pediatric dentist can provide such treatment in 25 states; orthodontists only in 13 states; either an orthodontist or a general dentist without restriction in 5 states; and only an orthodontist or pediatric dentist in 3 states. In Oklahoma, dentists are reimbursed through Medicaid for orthodontic services but must meet specific Oklahoma SoonerCare requirements. In Oregon, the provider can be any practitioner for whom the service is within the scope of practice. Arizona and Rhode Island did not specify eligible provider types (**Figure 1**).

Over the decade, some states have changed their rules regarding eligible providers. In 2006, 10 states restricted providers to be orthodontists. Since that time, six states (CO, IL, KS, MD, WV, and WY) changed to orthodontist only as a provider type, whereas three states moved away from restrictions to orthodontist only (DE, GA, and RI), allowing other dental practitioners to participate. Since the 2006 data did not include pediatric dentist as a category, a comparison could not be made.

Coverage by Patient Age

There are age limits for initiation of orthodontic treatment. In 2015, 42 states indicated that services must be initiated before age 21, before the age of 20 in 4 states, before age 18 in 3 states, and before the age of 16 in 1 state. Since 2006, 6 states have reduced the age for treatment initiation from before age 21 to before age 20 (NE, NV, TX, and UT) and before age 18 (NJ and OK). Oregon was the only state to increase the eligibility age by changing their restriction from age 18 to 21. Nine other states were listed in 2006 as "other" than 21. Six of those nine states previously listed as "other" have set the age for initiation of treatment before age 21 (AZ, CO, GA, LA, MN, and MT). The remaining three states (PA, SC, and WY) have specified eligibility ages as follows: PA, before age 23; SC, before age 16; and WY, before age 18 (**Figure 2**).

Qualifying Criteria

Various indices are utilized to classify malocclusion in 41 states. In 2015, the HLD index was used by 15 states, the HLD Cal Mod index by 4 states, the Salzmann index by 4 states, and the Salzmann index plus additional criteria in 4 states. The PCP Statement of Medical Necessity, HLD (NJ Mod or RI Mod), Colorado Orthodontic Criteria Index form, Idaho Smiles Malocclusion Index, DentaQuest Orthodontic Criteria Index form, or a combination of these, is used by 14 states. The remaining nine states either do not use an index or failed to report its use.

In contrast, only 34 states reported using an index in 2006. The Salzmann index was the most common with 11 states utilizing it, followed by the HLD index (10 states). Other indices were reported being used in 13 states. The remaining 16 states either did not use an index or failed to report its use (**Table 1**).

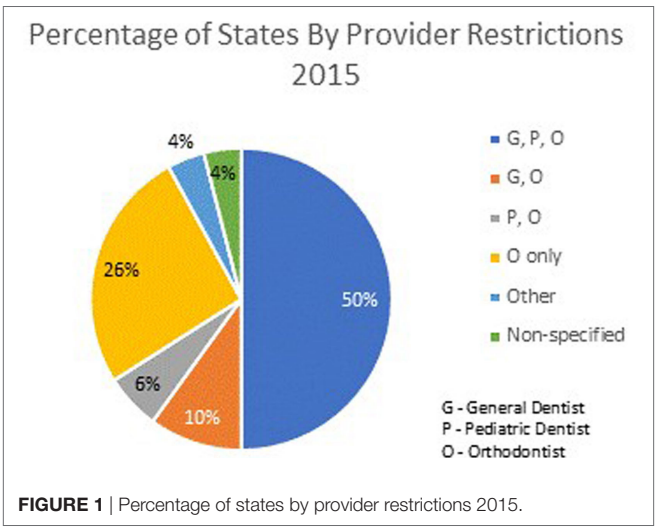

FIGURE 1 | Percentage of states by provider restrictions 2015.

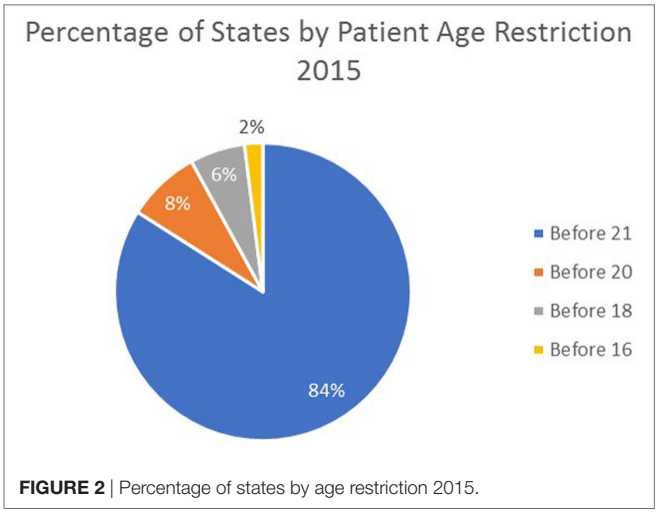

FIGURE 2 | Percentage of states by age restriction 2015.

TABLE 1 | Comparison of the number of states using an index to determine qualification.

	2015	2006
HLD	15	10
Salzmann	4	11
Salzmann + Mod	4	-
HLD CA Mod	4	-
HLD RI Mod	1	-
HLD NJ Mod	1	-
ID Smiles	1	-
Other	11	13
Total	41	34

HLD, Handicapping Labiolingual Deviation; Salzmann, Salzmann Index; Salzmann + MOD, Salzmann plus modifications; HLD CA Mod, Handicapping Labiolingual Deviation plus California Modifications; HLD Mod, Handicapping Labiolingual Deviation plus Rhode Island Modifications; HLD NJ Mod, Handicapping Labiolingual Deviation plus New Jersey Modifications; ID Smiles, Idaho Smiles Index.

Reviewers

The reviewer qualification for evaluating cases for eligibility varies by state. In 2015, the reviewer is exclusively an orthodontist in 18 states, must be a general dentist in 8 states, and exclusively a non-dentist in 6 states. Some states allow for more than one type of reviewer. For 11 states, the reviewer can be either an orthodontist or a general dentist. One state allows for an orthodontist or a non-dentist, whereas one other state allows for the reviewer to be an orthodontist, a general dentist, or a non-dentist. Five states did not report their criteria for reviewer qualification (AZ, KS, MA, SC, and TN) (**Table 2**).

The number of reviewers required to approve cases varies by state. In 2015, 13 states required only a single reviewer while 32 states required more than 1 reviewer. Five states did not report the number of reviewers used for case approval. Comparisons were not available for 2006.

Required Records

Records that must be submitted to assess eligibility vary by state and include combinations of models, cephalogram, panoramic radiograph, intraoral and extraoral photographs, tracings, treatment plans, PA cephalogram, signed statement from practitioner, and some additional forms. In 2015, study models were required in 27 states, cephalograms in 31 states, panoramic radiographs in 44 states, intraoral photos in 36 states, and other records were required in 29 states. By comparison, in 2006, study models were required in 31 states, cephalograms in 23 states, panoramic radiographs in 29 states, intraoral photos in 21 states, and other records in 29 states. Over the decade, more states are requiring submission of more types of records to justify Medicaid acceptance (**Table 3**).

Reimbursement Methods to Providers

Reimbursement schedules varied in 2015 with 19 states reimbursing by a single payment, 2 states with annual payments, 6 states by quarterly payments, 7 states by monthly payments, and 8 states reporting "other" payment methods. Three states used a combination method of reimbursement and five states did not report their payment methods.

TABLE 2 | Comparison of the number of states utilizing specific reviewer types.

	2015	2006
O	18	26
O, G	11	6
G	8	12
ND	6	5
No response	5	1
O, ND	1	-
O, G, ND	1	-

O, orthodontist; G, general dentist; ND, non-dentist.

TABLE 3 | Comparison of the number of states requiring specific types of orthodontic records.

	2015	2006
Models	27	31
Cephalometric	31	23
Panoramic	44	29
Intraoral photos	36	21
Other	29	29
Total	167	133

TABLE 4 | Comparison of the number of states by reimbursement schedules.

	2015	2006
Single	19	12
Annual	2	1
Biannual	0	1
Quarterly	6	8
Monthly	7	13
Other	8	14
Combination	3	0
No response	5	1

By comparison, in 2006, 12 states paid with a single payment, 1 state used annual payments, 1 state used biannual payments, 8 states paid quarterly, 13 states paid monthly, 14 states reported "other payment methods," and for 1 state, there was no report (DC) (**Table 4**).

Comparing the 2015 with 2006 reimbursement schedules, only 48% of states kept the same schedule for reimbursement, while 52% changed their reimbursement policy. The most prevalent change over time was a shift from quarterly or monthly reimbursement to a single payment.

Acceptance Rates

Acceptance rates for submitted cases vary by state. Of the reporting states in 2015, 2 states had a 20–40% acceptance rate, 7 states had 40–60% acceptance, 6 states had 60–80% acceptance, and 14 states had an 80–100% acceptance rate. This information was not provided in the 2006 data.

Expenditures

Total state expenditures varied from $75,242 to $29.5 million from FY 2013, 2014, or unspecified year. Total state expenditures were not reported in the 2006 data, so no comparisons were possible. The estimated cost of Medicaid orthodontic

treatment per capita was calculated for select states by dividing the state orthodontic expenditures by the 2015 estimated state population data obtained from the US Census Bureau (**Figure 3**) (19).

Reimbursement Rates

Reimbursement rates vary by state. For states with an initial payment followed by incremental payments based on treatment time, the reported rates are based on a 24-month comprehensive treatment time.

States were grouped into highest, midrange, and lowest reimbursement rates to parallel the classification approach used in the 2007 publication (1). In 2015, the highest reimbursement group ranged from $2,847.43 to $5,044 per case with an average of $3,719 and a median of $3,600. The midrange group varied from $1,200 to $2,847.14 with an average of $1,883.46 and a median of $1,754.16. The lowest group ranged from $493 to $1,200 with an average of $850 and a median of $872.31 (**Figure 4**; **Table 5**). When compared to the 2006 data, all levels of reimbursement have decreased with the lowest reimbursement region experiencing the greatest percentage decrease.

Medicaid reimbursement rates were grouped by geographic region in the same manner as reported by El-Gheriani et al. to parallel reporting by the ADA (1, 20). For 2015, the regional averages were as follows: New England, $2,718; Middle Atlantic, $826; South Atlantic, $1,973; East South Central, $1,636; East North Central, $1,691; West North Central, $2,250; Mountain, $2,392; West South Central, $2,888; Pacific, $2,653. The overall average of the regions was $2,114 (**Table 6**).

DISCUSSION

The financial crisis and resulting economic downturn that occurred in 2007 suggested the utility of updating the 2007 publication (1) to compare Medicaid expenditures for orthodontic services. Since the downturn, state budgets impacted by the nation's economy have strategically reallocated available funds to meet fiscal needs. Reported reimbursement rates have decreased since data were collected in 2006. Due to federal mandate, dental and orthodontic coverage was not eliminated, but per case expenditures were reduced. The only regions for which reimbursement increased from 2006 to 2015 are the New England and West South Central regions, which when adjusted for inflation do not likely constitute an increase.

The gap between the economically advantaged and disadvantaged American communities has increased since the "Great Recession" ended and a slow economic recovery ensued (21). A 2016 study by the Economic Innovation Group (EIG) found that, while prosperous zip codes are more populous and have flourished during the recovery, the economically distressed zip codes continue to be exceptionally hard hit and have failed to participate in the economic recovery (22). Their findings suggest that a deep and ongoing recession continues in these areas of the country which is affecting 50.4 million Americans. During the period from 2010 to 2013, the most economically depressed areas continued to lose jobs at a rate of 13%. Instead of business growth occurring during this time period, 1 in 10 business establishments closed. This can be contrasted to the most economically prosperous areas of America that experienced a 22% employment rise and where business establishments increased by 11% (22).

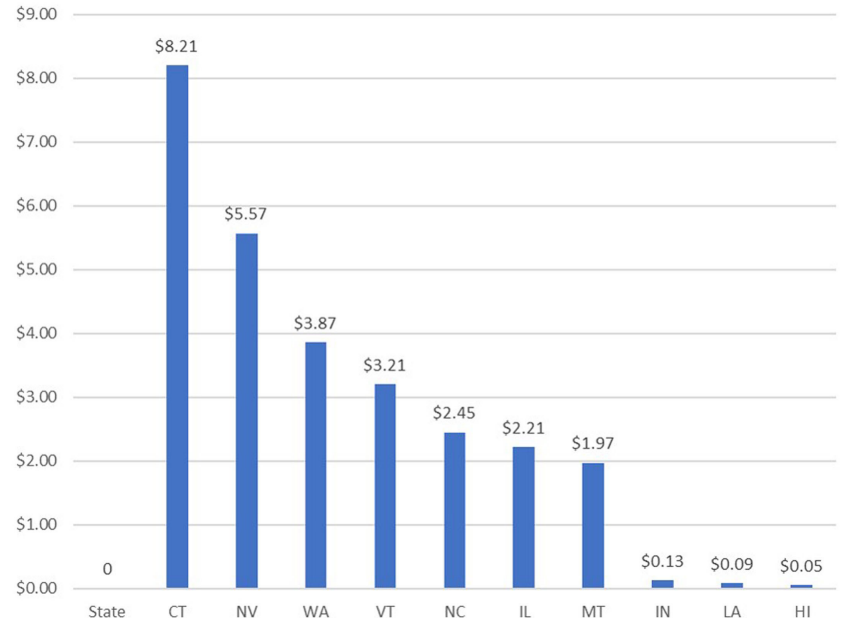

FIGURE 3 | Highest and lowest state expenditures per capita for Medicaid orthodontics.

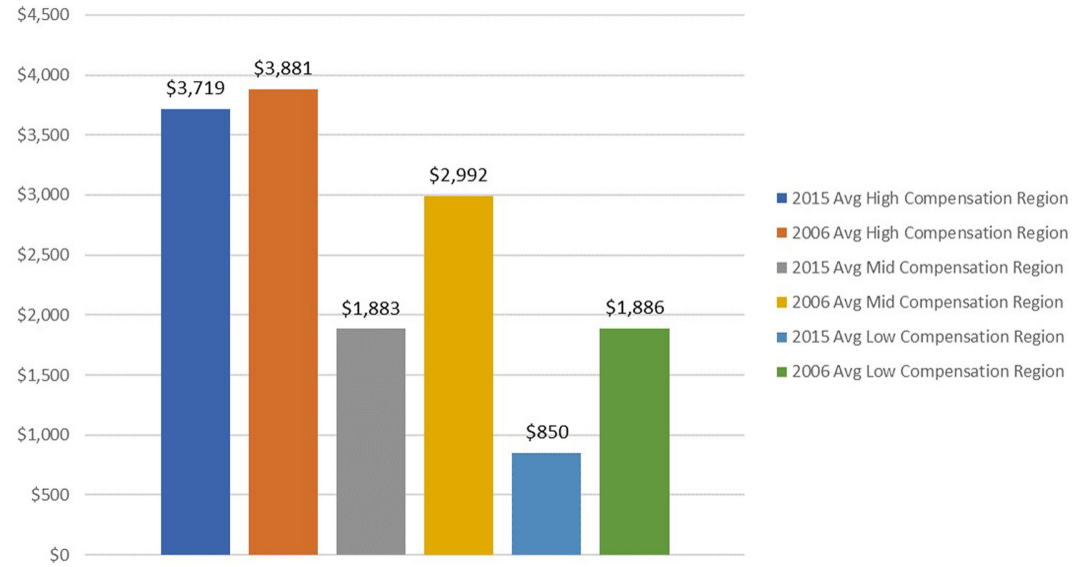

FIGURE 4 | Comparison of Medicaid orthodontic reimbursement rates 2006 and 2015 for high, mid, and low regions.

TABLE 5 | Medicaid orthodontic reimbursement rate change from 2006 to 2015 by region.

	2015			2006			% Change		
	Low	High	Average	Low	High	Average	Low	High	Average
Highest reimbursement region	$2,847	$5,044	$3,719	$3,200	$5,530	$3,881	−11.03%	−8.79%	−4.17%
Midrange reimbursement region	$1,200	$2,847	$1,883	$2,780	$3,178	$2,992	−56.83%	−10.41%	−37.05%
Lowest reimbursement region	$493	$1,200	$850	$775	$2,700	$1,886	−36.39%	−55.56%	−54.93%

TABLE 6 | Comparison of 2006 and 2015 reimbursement averages by region.

Region	2015	2006	% Change
New England (CT, ME, MA, NH, RI, VT)	$2,719	$2,575	5%
Middle Atlantic (NJ, NY, PA)	$826	$2,336	−183%
South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA, WV)	$1,973	$3,424	−74%
East South Central (AL, KY, MS, TN)	$1,636	$3,167	−94%
East North Central (IL, IN, MI, OH, WI)	$1,691	$3,226	−91%
West North Central (IA, KS, MN, NO, NE, ND, SD)	$2,250	$2,582	−15%
Mountain (AZ, CO, ID, MT, NV, NM, UT, WY)	$2,392	$3,162	−32%
West South Central (AR, LA, OK, TX)	$2,888	$2,801	3%
Pacific (AK, CA, HI, OR, WA)	$2,653	$3,225	−22%
Average	$2,114	$2,944	−39%

By examining the country by zip code, EIG was able to determine the geographic location of many of the depressed regions. They found that most of the economically stressed areas are concentrated in the nation's old industrial heartland and in the Deep South. By contrast, many of the prosperous areas are located in the Sun Belt and the western states. Areas such as the Rust Belt (Pennsylvania, West Virginia, Ohio, Indiana, Michigan, and Illinois) have experienced some economic rebound, but most of these states continue to languish in an economic recession (23).

In addition to the Great Recession, the ACA has impacted the healthcare system and state budgets since it was signed into law in 2010. Although the ACA was signed into law in 2010, changes in Medicaid did not take effect until January 1, 2014, with open enrollment beginning in October 2013. Under the new healthcare law, Medicaid, in general, underwent substantial changes including changes in eligibility and expanded coverage, modernization of the enrollment process, and increased outreach and enrollment efforts (24). The Kaiser Commission on Medicaid and the Uninsured found in a 2014 study that Medicaid and Children's Health Insurance Program enrollment outpaced its usual rate by an additional 4.8 million people (8.2% increase) within the first 6 months after the new Medicaid rules of the ACA went into effect (24).

While the ACA has been successful at reducing the number of uninsured Americans, it has also strained state budgets by rapidly increasing the number of Medicaid recipients receiving state-funded medical coverage (24). Since state budgets are funded by tax dollars that are collected from economic activity

occurring within a state, economically stressed states have felt a disproportionate amount of the financial burden of the ACA.

If a direct comparison between 2006 and 2015 of the number of dentists providing Medicaid orthodontic treatment were possible, it seems likely that the 2015 data would show a greater disparity in access to care among income groups due to changes in Medicaid eligibility, availability of providers, and a host of other factors; however, this is difficult to accurately measure. The authors of a recent study suggest that it is difficult to determine how many dentists actually participate in Medicaid due to the uncertainty created by indirect measurement techniques, since provider participation rates are often estimated by how extensively providers bill Medicaid and treat beneficiaries. Estimated low rates of dentist participation have often resulted in expressed criticism of dentistry for not sufficiently serving Medicaid beneficiaries (25).

Orthodontic care, while it is important and part of the federal mandate, may not be considered as critical as other medical procedures. As a result, since 2006, it is likely that states have reallocated some of their resources and reduced expenditures for orthodontics to reduce pressure on strained medical budgets. Since the 2006 study did not include state expenditures for orthodontic care, a direct comparison was not possible. However, in 2015, the importance some states have placed on provision of orthodontic care was illustrated by the state expenditures per capita in those states. On the upper end of the spectrum, Connecticut and Nevada spent $8.21 and $5.57, respectively, per capita. On the lower end of the spectrum, Louisiana and Hawaii spent on $0.09 and $0.05, respectively, per capita for provision of orthodontic care (**Figure 3**).

By comparing the highest, midrange, and lowest reimbursement groupings from the 2006 study to 2015, it is apparent that provider reimbursement has decreased (**Figure 4**). The greatest reduction of reimbursement over the past decade is in the middle and low reimbursement regions. The national average for Medicaid orthodontic reimbursement to providers decreased by 28% from 2006 to 2015 (**Table 7**). Regional comparisons of average Medicaid reimbursement rates generally reveal a decrease over the last decade, even without applying an inflation adjustment (**Table 6**). Some regions have seen larger decreases than others. Comparing the East North Central Region (comprised largely by Rust Belt states that have not shared as much in the economic recovery) to the Pacific Region, it is apparent that reimbursement rates have decreased significantly more in the East North Central Region (**Table 8**).

Comparison of private practice fees versus public reimbursement reported by the ADA 2016 Survey of Dental Fees (20) by selected region reveals that the discrepancy between private versus public pay has widened substantially (**Table 8**). Even economically stressed areas have seen increases in private practice orthodontic reimbursement rates from 2006 to 2015.

In addition to decreasing Medicaid reimbursements, the reluctance of some orthodontists to treat Medicaid patients relates to the fact that Medicaid funding can cease if a patient is no longer Medicaid qualified, even though orthodontic treatment is incomplete. This has the most impact in states that utilize a periodic reimbursement schedule. Orthodontists may be unwilling to treat a large number of Medicaid patients for fear of continued treatment needs long after payment for orthodontic services has been discontinued.

It is possible that, if existing laws were rewritten so that Medicaid was solely a federally subsidized program without state-based variability, equal access to care would improve. This would require the federal government to set reimbursement rates for regions using an approach similar to that utilized by private insurance companies. As long as reimbursement rates were kept reasonably competitive, compared to local fees, orthodontists would be encouraged to treat Medicaid patients, improving access for those currently underserved.

Restriction of types of dentists permitted to provide orthodontic care from 2006 to 2015 has decreased the number of Medicaid providers in several states. Eight states (CO, FL, IL, KS, MD, TN, WV, and WY) that allowed general dentists to provide orthodontic care in 2006 have restricted care to specialists in 2015. Medicaid-funded orthodontics can be provided only by an orthodontist in six states (CO, IL, KS, MD, WV, and WY). Pediatric dentists and orthodontists are permitted to provide care in two states (FL and TN). Since qualification for orthodontic care is limited to *handicapping malocclusions*, Medicaid-funded orthodontic cases by definition are more complex and often more difficult to treat successfully. While some may reasonably argue that specialists are better equipped to provide orthodontic care to these individuals, states that restrict care to specialists make it more difficult for patients to identify local providers. The Kaiser Family Foundation reports that as of April 2017, there were 146,526 actively practicing general dentists, 6,093 pediatric dentists, and 6,147 orthodontists in the United States. In the 6 states that have restricted Medicaid-funded orthodontics to orthodontists only, there are 14,778 general dentists, 541 pediatric dentists, and 882 orthodontists in active practice. Since orthodontists only constitute 6% of dentists licensed to and likely to perform

TABLE 7 | Comparison of adolescent orthodontic treatment reimbursement rates 2006 and 2015.

	2015	2006	% Change
Average Medicaid reimbursement	$2,114	$2,944	−28%
Average private practice reimbursement	$5,194	$4,670	11%
Medicaid as% of private practice reimbursement	41%	63%	−35%

TABLE 8 | Comparison of reimbursement rates between private practice fees and Medicaid fees for the East North Central Division and the Pacific Division 2006–2015 (20).

	2015	2006	% Change
East North Central Region (IL, IN, MI, OH, WI)			
Average Medicaid reimbursement	$1,691	$3,226	−48%
Average private practice reimbursement	$5,229	$4,660	12%
Medicaid as% of private practice reimbursement	32%	69%	−53%
Pacific Region (AK, CA, HI, OR, WA)			
Average Medicaid reimbursement	$2,653	$3,225	−18%
Average private practice reimbursement	$5,354	$4,889	10%
Medicaid as % of private practice reimbursement	50%	66%	−25%

orthodontic treatment in theses states, it is possible that patients may be forced to seek orthodontic treatment a distance from their community, adding an access to care barrier (26).

Patient age limits for treatment initiation have lowered in some states. While most states stipulate that orthodontic treatment must begin prior to a patient's 21st birthday, six states have reduced the age limit since 2006. The restriction is age 20 for four states (NE, NV, TX, and UT) and age 18 for two states (NJ and OK). The state of Oregon was the only state to raise the age restriction from 18 to 21 years during that time period. By lowering the age requirement, states decrease the number of potential patients that can be approved for Medicaid-funded orthodontic treatment. However, patients with the most severe malocclusions often require a combination of orthodontics and orthognathic surgery to achieve a successful result. In many cases, orthognathic surgery should only be performed once growth is complete, which for males is often in their early 20s (27). If states decrease the age limitation too severely, people with severe malocclusions most in need of corrective orthodontic treatment may be excluded, benefiting state budgets but not individuals.

Another mechanism for reducing the number of funded cases is the increased use of malocclusion indices. The number of states using indices to determine eligibility increased from 34 in 2006 to 41 in 2015. Although more objective, some indices do not consider the esthetic component of an individual's malocclusion. By removing a reviewer's ability to approve cases that constitute an obvious *handicapping malocclusion*, but fail to score appropriately on an index, states deny care to patients who are in need of orthodontic treatment. Some forms of *handicapping malocclusion* are not readily apparent without the use of human intelligence.

States have increased the number and types of records that must be provided by a practitioner to determine case eligibility (**Table 3**). The number of states requiring lateral cephalograms, panoramic radiographs, and intraoral photos has increased since 2006. In theory, the use of these records should increase the ability of the state reviewer to determine the need for treatment. However, it also increases patient chair time and overhead costs. For example, in 2015, reimbursement for intraoral photos ranged from $59 to $0 with an average reimbursement of $14. However, 19 states that require intraoral photographs for treatment approval do not reimburse for them. If the submission requirements become too arduous, providers may decide the additional hassle, and cost associated with provision of Medicaid orthodontic care is not justified. As a result, their acceptance of Medicaid patients will either be reduced or discontinued in favor of privately insured or fee-for-service patients, further increasing disparities.

In summary, decreases in Medicaid funding and changes in regulations and practices across states have resulted in considerable difference in the access to orthodontic care for handicapping malocclusions. The reasons for these changes are primarily economic but result in barriers of access for those in need. Further research could be done to examine policies and practices that could be altered to improve access.

Limitations

(1) The study spans the time frame of the Great Recession and the passage and rollout of the ACA, but the study is not designed to analyze causation. (2) The methodology follows that used in the 2006 study. Not all data collected in 2015 were gathered in 2006, making some comparisons impossible. Furthermore, the data categories collected in the 2006 study, such as geographic areas and reimbursement levels, were repeated in 2015 to allow comparisons. Other categories may have been selected for the 2015 study if direct comparisons had not been the goal. (3) The study does not include data on patients or providers, both of which might add information to considerations of barriers to (or disparities in) access to care.

CONCLUSION

1. There is extensive variation among Medicaid-funded orthodontic programs in the United States.
2. In the past decade, reimbursement rates for orthodontic services generally decreased by a range of 115–283%.
3. Continued regional economic strain and increased Medicaid enrollment resulting from the enactment of the ACA may be responsible for reductions in Medicaid-funded orthodontic reimbursements and tighter qualifiers for case acceptance.
4. Differences between state Medicaid programs create disparities in orthodontic care depending on a citizen's state of residency.

DECLARATIONS

Neither the institution nor any authors received payment or services from a third party for any aspect of submitted work. There are no financial relationships that have influenced or given the appearance of potentially influencing this work. There are no patents, copyrights, or royalties relevant to this work. There are no relationships or activities that have influenced or perceived to influence the content of this work.

AUTHOR CONTRIBUTIONS

GM and TT have written the re-submission. WS, SN, CC, AH, SW, and LO have all been involved in the project.

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Orthodontic Treatment Completion and Discontinuation in a Rural Sample from North Central Appalachia in the USA

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Background: Orthodontics has inherent demands, requiring regular appointments and active patient engagement, but relatively little is established in regard to rates of completion of treatment and possible factors affecting successful completion. These factors may be particularly important for cultural minority groups, such as those in rural Appalachia, given the environmental, social, and economic complexities affecting access to and utilization of treatment.

Design and methods: A naturalistic study design was employed, using retrospective data from a rural outpatient general dental office in July 2012. Chart abstraction yielded 219 (55.3% female) orthodontic patients (M age = 11.0 [3.7]). Chi-square tests for independence were conducted for categorical dependent variables. For continuous variables, *t*-tests were conducted. A logistic multivariate regression analysis was conducted to predict completion/non-completion of treatment, with age, gender, distance traveled, type of malocclusion, and payment type as predictors.

Results: Overall, 49.8% of this sample successfully completed orthodontic treatment. Greater successful conclusion of treatment was found in self-pay patients (i.e., 74%) versus those whose care was funded through Medicaid/Children's Health Insurance Program (i.e., 34%) or through private insurance (i.e., 36%). Age, gender, and distance to the office from home had no association relative to successful completion of treatment, although average one-way distance to travel for care was considerable (i.e., 38.8 miles).

Conclusion: Rate of successful orthodontic treatment completion was low in this rural sample. Treatment outcome was related to the form of payment for services, with self-pay associated with the highest rate of successful completion.

Keywords: orthodontics, dentistry, Appalachian region, rural, health disparities, treatment completion, adherence

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INTRODUCTION

The utilization of orthodontic treatment by cultural minority groups in the USA is significantly less than that of majority populations (1–4) in spite of treatment need that is at least as great (2, 4). This oral health disparity has important implications for appearance, employability, and self-esteem (5–7), in that lack of access to, and utilization of, orthodontic care is associated with lower oral

health quality of life, as well as other psychosocial and economic problems. In the region of Appalachia in the USA, this orthodontic disparity may be particularly pronounced due to a variety of environmental, social, economic, and geographic factors (8, 9). Known as a "neglected minority" (10), the Appalachian population has a number of positive, protective factors, but faces numerous problems and obstacles to good health as well (8, 11, 12).

Demands of Orthodontic Care and Impact on Adherence and Successful Completion

Orthodontic treatment is unique in that it requires active patient engagement and follow-through on an ongoing basis, typically with regular recall appointments, often at a developmental time of life (i.e., adolescence) in which there is opposition to demands and rules imposed by adults (13). The length of time involved in orthodontic care also is considerable, and can last two or more years, depending on various factors such as the severity of the malocclusion (14).

The classic conceptualization of malocclusion is from Angle, who posited that the relation of the first molars is central, with types including Class I (normal), Class II (lower molars behind the upper molars, causing top teeth to protrude), and Class III (lower molars in front of the upper molars, causing bottom teeth to protrude) (15). Ongoing adherence to oral hygiene, following instructions, wearing removable appliances, and appointment keeping throughout the duration of treatment can be quite challenging, leading to treatment discontinuation and failure.

Orthodontic Care in Low Income Populations

There are ethnic/racial disparities in utilization of orthodontic care in the USA, with certain minority groups less likely to have had at least one orthodontic visit compared to Whites, in spite of greater problems with malocclusion in some of those groups (1, 2). Access to care is a likely factor, along with various economic and other social issues that are related to both utilization and orthodontic outcomes. Contrasting Medicaid and private-pay patients in Washington state, higher orthodontic completion rates were found among the private-pay patients in a 2-year period; 22% of the Medicaid patients (versus 9% of the others) were judged to have "no improvement" in overall occlusion and esthetics based on standardized clinician assessment (16). Similarly, in Great Britain, lower socioeconomic (SES) status was found to be associated with discontinuing orthodontic care (17), and in the USA was identified as being associated with lower utilization of orthodontics (as was being male) (2). In an investigation of Medicaid-funded orthodontic services in Iowa, children and adolescents living in rural areas and small towns were found to be more likely to utilize orthodontic services relative to those who were urban dwellers (18). A higher rate of appointment failures was found in a sample of Medicaid versus other-pay orthodontic patients at a school of dentistry clinic in Virginia (19).

Orthodontic Care in Appalachia

A region in the eastern USA that is comprised of 530,948 km^2 (205,000 miles), Appalachia is shaped by the Appalachian mountain range; as a region, it spans 13 states in the USA, and encompassing all of West Virginia (20). Socioeconomically diverse, much of Appalachia is rural (42% of the population, compared to 20% nationally) and beset by social problems and health disparities (20).

The cultural heritage and values associated with Appalachia include self-reliance, strong religious ties, and loyalty; many groups in Appalachia are composed of peoples who are proud, private, and patriotic, who want to "take care of their own," and are reluctant to accept charity (11). Lengerich noted that even though this area is faced with limited economic opportunities, and for some, pervasive poverty, many Appalachian communities remain vibrant, and may be a substantial source of its residents' strength (12).

The mountainous topography shapes lives and culture in Appalachia; access to health care, particularly with specialists, has been hindered by the mountainous terrain, inadequate roads, and transportation systems, and lack of interest of specialists to locate in these areas. This situation continues to demand that patients seek treatment from general health-care professionals (e.g., dentists in general practice) because of lack of access to specialists (e.g., orthodontists), including the distances they would have to travel to receive specialized care.

Research on oral health in Appalachia is growing (21), but as yet only includes a modicum of data on orthodontics. In a sample of 12- to 17-year-old adolescents and their parents in Appalachia, degree of unmet treatment need and history of orthodontic care were similar to the national norms in the youth, although a significant amount of unrecognized and untreated orthodontic need existed in the parents (22). Of additional concern was that demand for orthodontic care among the youth was lower than clinically identified need and less than published norms, which was suggested as possibly being related to oral health values (23). Given the array of oral health issues in Appalachia (21), more information is needed about orthodontic care, given its lifelong implications for occlusion, functionality, and oral health quality of life.

Objectives and Hypotheses

With reports from practitioners in the field suggesting an alarming rate of orthodontic treatment discontinuation in some population subgroups in Appalachia, this study aimed to document the scope of the problem and to identify possible factors that predict treatment completion and discontinuation. Some prior research has included large datasets from state-based samples [e.g., Ref. (18)], so this study focused on naturalistic data from a single general dental practice in North Central Appalachia. It was hypothesized that successful completion of orthodontics would be related to type of financing for the care [i.e., self-pay, insurance, or government-funded programs including Medicaid and the Children's Health Insurance Program (CHIP)], with self-pay patients having the highest completion rate. Given the unique nature of the Appalachian sample and environment, as well as oral and other health problems in the region, secondary hypotheses included an array of demographic, orthodontic, and psychosocial factors that the literature has considered in terms of successful completion or possible adverse effects (e.g., promoted discontinuation of

treatment), specifically including age at treatment initiation, gender, and distance traveled between home and the office for orthodontic care, and malocclusion type.

MATERIALS AND METHODS

A retrospective cohort design was utilized, with data based on existing health records from a rural general dental practice in North Central West Virginia. For a 5-year period (i.e., 2007 through 2012), only records that were completed or inactive for six or more months were included. As this study is a naturalistic one, the only available data were those that already existed in the health records that were utilized in a practice setting.

Participants and Practice Characteristics

Health records were located for a total of 219 outpatients (121 females, 98 males) with an average age of 11.0 years (SD = 3.7) from a solo private general dental practitioner's office in rural central West Virginia. The dentist was a general practitioner with training in orthodontics. The office was situated in a rural Appalachian community with a population of approximately 4,100 inhabitants. The county including this community had an estimated population of 16,309, with a 97.9% being Caucasian, 14.1% with a college degree or higher, and 20.6% living below the federal poverty level (24). On the 9-point Rural-Urban Continuum Codes (with 1 = urban and 9 = completely rural), the target county had a rurality status of 7.0, indicating a county with a population of 2,500–19,999, which is not adjacent to a metropolitan area (25).

Chart Abstraction and Procedure

Data were abstracted from each health record by a single trained dental hygienist (BD) using a standard form. All relevant demographic information available in the chart was recorded (e.g., age at treatment initiation, gender, distance traveled between home and the office for orthodontic care, length of treatment) as was form of payment (i.e., private insurance, Medicaid, CHIP, and self-pay). Also recorded was the Angle's classification of the occlusion of each patient, as determined by the dentist. Successful completion or non-completion was recorded, and, as applicable, reason for non-completion [i.e., ongoing poor oral hygiene (as determined by the dentist), parent/guardian request, removal by patient].

Variable Definitions and Statistical Analyses

The primary outcome variable, treatment completion, was created as a dichotomous indicator of whether or not the patient successfully completed treatment (i.e., termination of active treatment with fixed appliances removed by dental staff at the direction of the dentist after a course of treatment that adequately addressed clinical need). Chi-square tests for independence (with Yates Continuity Correction for 2 × 2 analyses) were conducted for categorical dependent variables. For continuous variables, *t*-tests were conducted. Certain variables were combined in particular analyses due to small sample sizes or for clarity of presentation [i.e., Medicaid ($n = 171$) and CHIP ($n = 5$) patients were combined into one group; Divisions 1 and 2 in Class II malocclusion were combined in certain analyses]. To provide an overall perspective on possible determinants of treatment outcome considering possible determinants as a whole, a logistic multivariate regression analysis was conducted to predict completion/non-completion of treatment, with age, gender, distance traveled, type of malocclusion, and payment type as predictors; variables were treated as categorical or continuous, as appropriate.

RESULTS

Overall, only one-half of all patients successfully completed the prescribed course of orthodontic treatment (i.e., 109 of 219 patients, 49.8%). Reasons for discontinuation included ongoing poor oral hygiene (35.4%, $n = 39$), parent/guardian request (47.3%, $n = 52$), or removal by patient (17.3%, $n = 19$). The distribution of malocclusion across patients was as follows: Class I—15.5% ($n = 34$), Class II (Division 1)—66.7% ($n = 146$), Class II (Division 2)—7.3% ($n = 16$), and Class III—10.5% ($n = 23$).

In regard to the first hypothesis, completion rates differed across payment types, $\chi^2(2, N = 219) = 17.95$, $p < 0.0005$; Cramér's V = 0.29, $p < 0.0005$. Self-pay patients had a treatment completion rate that was approximately twice that of the other groups, as shown in **Figure 1**.

Regarding secondary hypotheses, age did not differ between groups [completers: M = 11.4, SD = 4.4; non-completers: M = 10.6, SD = 2.8; $t(217) = 1.56$, $p = 0.12$], nor did gender [completers: males—41% ($n = 45$), females—59% ($n = 64$); non-completers: males—48% ($n = 53$), females—52% ($n = 57$); $\chi^2(1, N = 219) = 1.10$, $p = 0.31$; Cramér's V = 0.07, $p = 0.31$]. Distance traveled (one-way) between home and the office for orthodontic care was considerable for some patients (i.e., up to 180 miles; M = 38.8 miles, SD = 32.3), but also did not differ between completer groups, $t(217) = 0.29$, $p = 0.78$. Distribution of type of malocclusion across groups did not differ [completion rate: Class I = 18 of 34, 53%, Class II (Division 1) = 77 of 146,

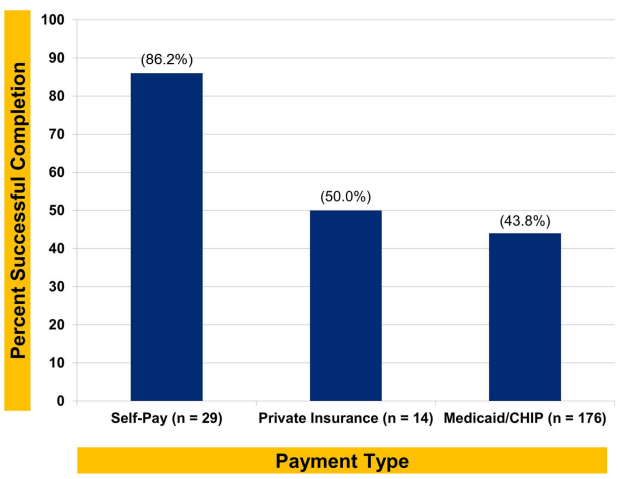

FIGURE 1 | Successful orthodontic completion rate by payment type.

53%, Class II (Division 2) = 7 of 16, 44%, Class III = 7 of 23, 30%; χ^2 (1, $N = 219$) = 4.32, $p = 0.23$; Cramér's V = 0.14, $p = 0.23$].

The logistic multivariate regression analysis with completion/non-completion of treatment as the dependent variable, and age, gender, distance traveled between home and the office for orthodontic care, malocclusion classification, and payment type as predictors revealed that Medicaid/CHIP and private insurance payment types were significantly related to premature termination of treatment, as indicated in **Table 1**.

DISCUSSION

Payment type was found to be the singular variable that distinguished patients who either did or did not successfully complete orthodontic treatment in this rural Appalachian sample, with an approximately medium effect size (i.e., Cramér's V = 0.29) (26). Overall, self-pay patients had a rate (i.e., 86.2%) of successful treatment completion that was twice that of patients whose care was funded by Medicaid/CHIP; privately insured patients had only slightly higher completion rates than the Medicaid/CHIP patients. While payment for orthodontic services through Medicaid may be a proxy for socioeconomic status, with its established relation to health and health behaviors, the fact that completion rates for patients who had private insurance were similar (i.e., 43.8% for Medicaid and 50.0% for private insurance) suggests other influences also affect outcomes.

It should be noted that one of the statistical approaches (i.e., regression) suggested the possibility that Class III malocclusion may be associated with greater premature discontinuation of treatment relative to Class I, although the findings do not reach a standard level of statistical significance. It may be that Class III malocclusion as a condition, with the lower teeth protruding, may be less noticeable and thus less socially compelling for patients to complete treatment.

TABLE 1 | Logistic multivariate regression predicting treatment completion/non-completion.

Adjusted logistic regression	*B* (SE)	Adjusted odds ratio [95% CI]	*p*
Age	−0.08	0.93 [0.83, 1.03]	0.16
Gender			
Male	−0.32	Reference	
Female		0.73 [0.99, 1.01]	0.27
Distance (traveled between home and office)	0.001	1.00 [0.99, 1.01]	0.88
Malocclusion type			
Class III		3.39 [0.96, 11.97]	0.058
Class II (both divisions)		0.87 [0.39, 1.94]	0.74
Class I		Reference	
Payment type			
Medicaid/Children's Health Insurance Program		10.08 [3.12, 32.50]	<0.0005
Private insurance		7.55 [1.57, 36.23]	0.012
Self-pay		Reference	

R^2 = 0.126 (Cox and Snell), 0.168 (Nagelkerke). Model $\chi^2(7) = 29.52$, $p < 0.0005$. Premature termination was coded as 1, and successful completion of treatment was coded as 0.

Cognitive dissonance theory (27, 28) implies that when one invests in a task (e.g., with money, time, or other resources), then one values it to a greater degree, and has more motivation to successfully accomplish it. Patients paying for psychotherapy, for example, tend to benefit more from services than those who are not directly responsible for fees (29). These results prompt consideration of orthodontic payment structures that involve a broad analysis of cost sharing and value for health care, such as in "value-based insurance design" (30, 31). Indeed, behavioral economics approaches have much to offer in terms of improving patient care and practice management in oral health-care settings (32).

These present findings are in many ways similar to those of Mandall and colleagues (33) in a British multi-site study of orthodontic care, who found a 57% completion rate, with poor oral hygiene and multiple failed appointments being the primary reasons for treatment discontinuation. Not dissimilarly, about half of the current Appalachian patients successfully completed orthodontic care, with poor oral hygiene being one of the top three reasons for discontinuation, along with parent/guardian request, and removing appliances at home. Data from a USA urban sample unfortunately are not readily available that would allow comparison with the current findings. Regardless, however, the orthodontic completion rates are quite low, which suggests need for intervention. The present study also found no significant relation between orthodontic outcomes and patient age, gender, or distance between home and the dental office, which is consistent with the Mandall (33) study, although there is some suggestion that Class III malocclusion may be associated with greater premature treatment termination. This latter investigation also noted no relation between orthodontic treatment adherence or orthodontic outcome with demographic factors (including SES), quality of life measures, or clinically determined treatment need (33).

This study is limited in that the sample is from a specific (Appalachian) cultural group in a rural area. At the same time, the sample reflects the ethnic/racial distribution of the region; the unique environmental and social factors affecting this population have implications for other rural and cultural minority groups. Additionally, the sample is limited to a single dental practice in a rural location. Nevertheless, such practices often are isolated, with no specialists available, in rural, low density population areas in Appalachia and elsewhere.

CONCLUSION

This study determined that method of payment was related to orthodontic treatment completion, with self-pay patients having twice the rate of successful completion of care, relative to those whose care was funded publically. Consistent with other, international research, there was no relation between treatment completion and demographics, Angle's malocclusion classification, age, gender, one-way distance traveled for treatment, or length of treatment. Based on 219 orthodontic patients from a general dentistry rural practice in central West Virginia, these results have implications for cultural minority groups receiving orthodontic and other oral health care in rural Appalachia and other rural locales. Given the negative

impact of malocclusion on the psychosocial well-being of adolescents (34) and others, and even their academic performance, these findings highlight the importance of developing strategies that will help prevent premature termination of orthodontic care.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the American Dental Association Principles of Ethics and Code of Conduct, as well as the American Psychological Association Ethical Principles of Psychologists and Code of Conduct. The protocol was determined to be exempt (protocol #1705579750), as acknowledged by the West Virginia University Institutional Review Board.

AUTHOR CONTRIBUTIONS

CM was engaged in study conceptualization, data collection, data analysis/interpretation, and analysis. He provided orthodontic expertise for this project. Additionally, he wrote initial drafts of the paper, and reviewed the final paper and provided editorial comments. BD abstracted the data from the health records, and was engaged in study conceptualization, data collection, data analysis/interpretation, and analysis of results. She reviewed the final paper and provided editorial comments. DM provided expertise in conceptualizing the research questions and hypotheses, as well as research design and analysis. Additionally, he was engaged in all aspects of the current project, leading study conceptualization, data collection, data analysis/interpretation, results writing, and preparation of the manuscript for publication. He edited initial drafts of the paper and wrote the final draft of the paper.

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Enabling and Predisposing Factors for the Utilization of Preventive Dental Health Care in Migrants and Non-Migrants in Germany

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Background: In many European countries including Germany, migrants utilize preventive services less frequently than the majority population. This is also true for the utilization of dental checkups. Little is known about which demographic, social, behavioral, and health-related factors influence the decision of migrants to seek preventive dental health care and how these factors differ from those in non-migrants. The aim of the present study was to examine the role of these factors among migrants and non-migrants residing in Germany.

Methods: Data from cross-sectional national health surveys are used, providing information on preventive dental health behavior from $n = 41{,}220$ individuals, of which 15.0% are migrants. Andersen's Behavioral Model of Health Services Use is the conceptual framework of the investigation. Multiple logistic regression models were applied to examine the role of different predisposing and enabling factors. Interaction terms were included in order to examine whether determinants differ between migrants and non-migrants. Average marginal effects (AMEs) are reported in addition to odds ratios (ORs) as measures of effect size which are robust against bias arising from unobserved heterogeneity.

Results: Migrants are at an about 36% lower chance of utilizing regular dental checkups than non-migrants [OR = 0.64 (95% confidence interval, 95% CI: 0.61, 0.68); AME = −0.081 (95% CI = −0.093, −0.069)]. Differences are partly explained by the influence of demographic, social, behavioral, and health-related factors [adjusted OR = 0.69 (95% CI: 0.64, 0.73); AME = −0.065 (95% CI = −0.076, −0.053)]. Younger age, being male, lower socioeconomic status, a non-statutory health insurance, not living in a relationship, living in the Western part of Germany and in an urban setting, and poor limited social support were associated with a lower chance of utilizing regular dental checkups. Interaction effects could be observed for age and for the type of health insurance.

Discussion: The study identifies different enabling and predisposing factors that are relevant for the utilization of dental checkups among the population in Germany, some of which differ between migrants and non-migrants. Differences are particularly pronounced for younger ages. This differs from findings on other preventive services where

older migrants tend to be more disadvantaged. Additional explanatory factors such as barriers that migrants experience in the dental health care system need to be considered in order to implement patient-oriented services and to reduce disparities in access to dental prevention.

Keywords: migrants, oral health, disparities, utilization, Germany

INTRODUCTION

In many European countries including Germany, large proportions of the respective populations are migrants (1). This comprises both foreign nationals and nationals of the respective countries who have an immigrant background because they or their parents immigrated from another country. In Germany, around one-fifth of the total population of 81.4 million people are migrants, totaling about 17.0 million individuals (2).

Migrants utilize preventive measures, such as screening, less frequently than the majority population of the respective host countries (3, 4). This is also true for the utilization of regular dental checkups (5–7), which can be considered an important aspect of maintaining and promoting oral health (8–12).

Studies addressing differences in health care utilization between population groups have increasingly used Andersen's Model of Health Services Use or variations of it to identify determinant factors (13). Concerning dental services and especially dental prevention, a few studies are available that used this model to identify determinants of service use (12, 14–16). The model distinguishes between three types of individual factors that facilitate or impede access to and utilization of health care services: predisposing, enabling, and need factors (17, 18). Predisposing factors identified in the dental care setting include sociodemographic determinants such as age, sex, socioeconomic status (SES), family status, immigration status, and aspects such as health literacy and health beliefs (11, 19, 20). Enabling factors refer to individual or structural resources enabling or increasing the likelihood of service use. In dental care, this includes aspects such as income, health insurance coverage, availability of health services or regular sources of care, and means of transportation (16, 21–23). Need factors in dental care encompass indicators of objective need of health care, such as toothache, denture wearing, carious and decayed surfaces, or other indicators of oral disease, as well as perceived (subjective) need (19, 20, 22, 23). In terms of migration, previous studies—most of which, however, did not use Andersen's model as their theoretical framework—focused on how the proportion of those not utilizing dental prevention differs between migrants and non-migrants of different age groups (6, 7, 9–12, 24–26). Little is known about which demographic, social, behavioral, and health-related factors influence the decision of migrants to seek preventive dental health care and how these factors differ from those in non-migrants. The aim of the present study was to examine the role that these factors have for the use of dental checkups in migrants and non-migrants residing in Germany. Insights can help to inform the implementation of patient-oriented services and to reduce disparities in access to dental care.

MATERIALS AND METHODS

Data

The analysis is based on secondary data from two cross-sectional telephone surveys ("German Health Update 2009" and "German Health Update 2010"), carried out between July 2008 and July 2010 by the Robert Koch Institute, a scientific institution of the German Federal Ministry of Health (27). Data were collected by means of a random digits approach. The aim of the surveys was to inform about the health status and the health behavior of the population in Germany aged 18 years or older who lived in a private household with a landline telephone. Both surveys used a similar core set of questions which also covered the outcome of utilization of dental checkups in the 12 months prior to the interview. As the survey has only been conducted in German language, it is only representative for migrants with good German language proficiency. Data from both surveys have been pooled for the present study. The survey data collected by the Robert Koch Institute fulfils all necessary requirements and guidelines of the Federal data protection act. The telephone survey was voluntary and anonymous. Participants provided their oral informed consent before participating in the survey (27). As the study was observational (so no experiments were conducted), no further ethical approval was necessary (28). Given that patients were sampled by means of random digits dialing and that the questionnaire was administered *via* telephone obtaining a written informed consent was not feasible.

Variables

In the analysis, we compare migrants and non-migrants. In line with the procedure in other studies (29), migrants were defined as individuals who had migrated to Germany themselves or of whom at least one parent had migrated to Germany. Since only German-speaking adults were included, the sample is not representative for migrants with low or no proficiency of the German language.

As predisposing factors according to the Andersen model, sex, age (5-year age groups treated as a continuous measure), SES [low, middle, and high; based on a measure summarizing vocational educational, occupational status, and net equivalent income (30)], and marital status (living with a partner vs. not living with a partner) were taken into account. As enabling factors according to the Andersen model, the type of health insurance (statutory, private/other), social support [poor, moderate, and strong; based on the Oslo-3 Social Support Scale (31)], the place of residence (West Germany, East Germany), and the type of residence (urban, rural) were considered. The

place and type of residence were included to take into account regional differences in the availability of dental services (see **Table 1** for an overview of determinants of service use included in the analyses and for a description of their measurement). The outcome of our study was utilization (yes/no) of dental checkups in the last 12 months prior to the survey based on self-reports by respondents.

Analysis

Aside from a sample description stratified by migration status using chi-square tests and Wilcoxon–Mann–Whitney tests where appropriate, we used a multivariable logistic regression model to examine predisposing and enabling factors associated with the use of dental services (32). All variables were entered at once, i.e., no backward/forward selection has been performed. In order to examine whether predisposing and enabling factors differ between migrants and non-migrants, we included interaction effects between all predisposing/enabling factors and migration status one by one into the model and tested for significance. Considering that the evaluation of interaction effects based on odds ratios (ORs) may be biased because of unobserved heterogeneity (33), we calculated average marginal effects (AMEs) with their respective 95% confidence interval (95% CI) along ORs. AMEs represent differences in the probability for the occurrence of the outcome. Analyses were conducted using Stata 13 (34). As models with interaction terms are difficult to interpret, we only present AMEs of significant interactions.

RESULTS

Information on $n = 41{,}220$ subjects was available, of which 15.0% were migrants. In terms of the distribution of predisposing and enabling factors, some differences between both populations could be identified. Migrants were on average younger than non-migrants, had a lower SES, were more often insured by means of statutory health insurance instead of private health insurance, and lived more often in urban settings as well as in the Western part of Germany. The percentage of individuals reporting a lower social support was also higher among migrants. Only small differences could be observed in terms of sex ratio and the proportion of individuals who lived together with a partner (**Table 2**).

Migrants were at an about 36% lower chance of utilizing regular dental checkups than non-migrants, corresponding to an 8% point lower likelihood of utilization (OR = 0.64; AME = −0.081). Differences are partly explained by the influence of predisposing and enabling factors (OR = 0.69; AME = −0.065). Younger age, being male, lower SES, a non-statutory health insurance, and poor social support were associated with poor utilization of regular dental checkups (**Table 3**). Also, individuals who did not live in a relationship, who resided in the Western part of Germany, and who lived in an urban setting were at a lower chance of utilizing regular dental checkups.

As an inspection of interaction effects based on marginal effects shows, respondents with a private/other health insurance were less likely to utilize this form of dental prevention among non-migrants, whereas no differences between both types of health insurance with respect to their relevance for the utilization of dental checkups could be observed for migrants. In the case of age, also the direction of the association differed. Although older individuals without migration background were less likely to utilize dental checkups than younger individuals, it were older individuals among migrants who were more likely to utilize this form of dental prevention than younger respondents (**Table 4**). No other interaction effects were significant and hence are not reported.

TABLE 1 | Potential determinants of service use included in the analyses and description of measurement.

Factors included		Measurement: questions/scales/psychometric instruments	Categories of the variables/ response options
Predisposing	Age	Calculated from year and month of birth	5-year age groups (treated as a continuous measure)
	Sex	Self-reported	Male, female
	Living with a partner	Summarized indicator based on three questions: (1) Are you married? (2) If not: do you have a stable non-marital partner? (3) Do you live together with your partner/spouse?	Yes, no
	Migration status	Summarized indicator based on two questions: (1) Were you born in the area of the current Federal Republic of Germany? (2) Were both your parents born in the area of the current Federal Republic of Germany?	Migrant, non-migrant
	Socioeconomic status	Metric index measure including information on vocational training, level of education, occupational status and net equivalent income (3–21 points) (30)	Low (first quintile), middle (second to fourth quintile), high (fifth quintile)
Enabling	Social support	Oslo-3 Social Support Scale (31)	Weak, moderate, and strong
	Health insurance	Self-reported health insurance status	Statutory, private, or others
	Place of residence	Based on self-reported district and state of residence	West Germany, East Germany (including Berlin)
	Urbanity	Based on self-reported size of the city/town of residence	Urban, rural

TABLE 2 | Sample description by migration status (German Health Update 2009/2010 survey, *n* = 41,220).

Factor	Level	Non-migrant, *n* = 36,702	Migrant, *n* = 6,605	*p*-Value
Sex	Male	15,891 (43.3%)	2,823 (42.7%)	0.40
	Female	20,811 (56.7%)	3,782 (57.3%)	
Socioeconomic status	Low	3,588 (9.8%)	1,177 (17.9%)	<0.001
	Middle	20,651 (56.4%)	3,601 (54.6%)	
	High	12,403 (33.8%)	1,815 (27.5%)	
Health insurance	Statutory	29,993 (81.7%)	5,867 (88.8%)	<0.001
	Private or others	6,709 (18.3%)	738 (11.2%)	
Living in a partnership	Yes	22,731 (62.2%)	3,955 (60.1%)	0.001
	No	13,799 (37.8%)	2,622 (39.9%)	
Place of residence	East	7,409 (20.2%)	717 (10.9%)	<0.001
	West	29,293 (79.8%)	5,888 (89.1%)	
Urbanity	Urban	25,014 (68.6%)	5,279 (81.0%)	<0.001
	Rural	11,423 (31.4%)	1,236 (19.0%)	
Social support	Weak	4,618 (13.0%)	1,152 (18.2%)	<0.001
	Moderate	17,718 (49.9%)	3,212 (50.8%)	
	Strong	13,173 (37.1%)	1,960 (31.0%)	
Age	18–24 years	3,669 (10.0%)	1,132 (17.1%)	<0.001
	25–29 years	2,143 (5.8%)	675 (10.2%)	
	30–34 years	2,363 (6.4%)	737 (11.2%)	
	35–39 years	3,121 (8.5%)	736 (11.1%)	
	40–44 years	4,410 (12.0%)	704 (10.7%)	
	45–49 years	4,206 (11.5%)	594 (9.0%)	
	50–54 years	3,482 (9.5%)	467 (7.1%)	
	55–59 years	3,267 (8.9%)	419 (6.3%)	
	60–64 years	2,634 (7.2%)	370 (5.6%)	
	65–69 years	2,916 (7.9%)	315 (4.8%)	
	70–74 years	2,301 (6.3%)	248 (3.8%)	
	75–79 years	1,118 (3.0%)	119 (1.8%)	
	80–84 years	726 (2.0%)	65 (1.0%)	
	85+ years	346 (0.9%)	24 (0.4%)	

TABLE 3 | Multivariable logistic regression model with utilization of dental checkups in the previous 12 months as the dependent variable.

Factor	OR	95% CI	AME	95% CI
Migrant (Ref: non-migrant)	0.69	0.64; 0.73	−0.064	−0.076; −0.053
Age	0.98	0.98; 0.99	−0.003	−0.004; −0.001
Female sex (Ref: male)	1.91	1.82; 2.00	0.106	0.098; 0.114
SES (Ref. low)				
Middle	1.78	1.65; 1.91	0.109	0.095; 0.124
High	2.61	2.40; 2.84	0.167	0.152; 0.183
Private health insurance (Ref: statutory)	0.75	0.70; 0.80	−0.048	−0.060; −0.036
Living in a partnership (Ref: not living in partnership)	1.63	1.55; 1.71	0.081	0.072; 0.089
Place of residence in Western Germany (Ref: Eastern Germany)	0.85	0.80; 0.91	−0.025	−0.035; −0.015
Living in an urban setting (Ref: Living in rural setting)	0.91	0.86; 0.96	−0.015	−0.023; −0.006
Social support (Ref: weak)				
Moderate	1.25	1.17; 1.34	0.038	0.026; 0.050
Strong	1.38	1.29; 1.49	0.054	0.041; 0.067

ORs, odds ratios; AMEs, average marginal effects, including 95% confidence intervals (95% CI). No interaction effects included (German Health Update 2009/2010 survey, n = 41,220).

TABLE 4 | Results of an interaction analysis regarding differing associations of predisposing/enabling factors and utilization of regular dental checkups between migrants and non-migrants.

	Non-migrants		Migrants	
	AME	95% CI	AME	95% CI
Age	−0.004	−0.005; −0.003	0.006	0.003; 0.01
Private health insurance (ref: statutory)	−0.05	−0.07; −0.04	−0.002	−0.04; 0.03

AMEs, average marginal effects, including 95% confidence intervals (95% CI). Only significant interactions presented (German Health Update 2009/2010 survey, n = 41,220).

DISCUSSION

The aim of the present study was to examine enabling and predisposing factors for the utilization of preventive dental health care in migrants and non-migrants in Germany based on data from two national telephone surveys. The study identifies different enabling and predisposing factors that are relevant for the utilization of dental checkups among the population in Germany. The findings are in line with those of previous research which has been conducted on the utilization of dental services in other countries. For example, an investigation from Denmark has also found that females and individuals living in a partnership have a higher likelihood of utilizing dental prevention (12). Similarly, a higher SES has been found to increase the chance for preventive measures in general (35, 36) and for utilizing dental prevention in particular (16, 19, 37). In our study, individuals with a private instead of a statutory health insurance were at a lower chance of utilizing dental prevention. This may be related to differences in copayment and reimbursement agreements (38). Differences were also observed with respect to place of residence and type of residence area. Studies have shown that although there has been a convergence of the prevalence of oral health impairment and the utilization of dental health services between East and West Germany, regular dental visits are still more common among East German adults (39, 40). Similar findings have been documented for German children (41). A recent study found increasing geographical differences in the ratio of dental service demand and supply, with few clusters of overserviced units in or around urban areas compensating demand for larger numbers of underserviced areas (supporting central place theory) (42).

Our study also reveals that migrants utilize dental checkups less frequently than non-migrants. Differences are only partially explained by the different enabling and predisposing factors which we were able to take into account as a multivariable analysis adjusting for these factors shows. This corresponds to findings from other studies (9–12) and suggests that additional factors associated with migration status need to be considered when addressing differences in the utilization of dental prevention. Access to dental prevention may be, similar to access to prevention in general, limited by factors on the patient, provider, and system level. Factors on the patient level comprise, for example, disadvantageous perceptions and beliefs of health and illness and a low health literacy (28, 43, 44). These could be relevant need and

predisposing factors as conceptualized by the Behavioral Model of Health Services Use (17, 18). Factors on the provider and system level include among others a poor cultural and migrant sensitivity of services (3, 44, 45). Future studies need to explore which patient-, provider-, and system-level actors are most relevant for the low utilization of dental prevention in migrants.

Although most predisposing and enabling factors did not significantly differ between migrants and non-migrants, the study showed that considerable age-related differences existed. While higher age was associated with a decreasing likelihood for the utilization of dental prevention in non-migrants, the association was reversed in migrants. Since there was no information on the time of immigration available in the data set and no differentiation between individuals who migrated themselves and those with immigrant parents was made, this effect at least in part could be related to acculturation processes and increased familiarity with the German health system (46).

The negative effect of a private insurance on the utilization of dental prevention could only be observed for non-migrants. A negative association between having a private insurance and using dental checkups has been found among non-migrant children and may be due to differences in cost, since dental prevention is covered by the statutory health insurance, but not necessarily by private health insurance contracts (47). The fact that a lower chance could only be observed for migrants could be related to differences between migrants and non-migrants in willingness to pay for dental checkups. This assumption, however, has to be verified by further studies.

Strengths of the analysis are the large size of the sample and the high quality of the gathered information. There are also some limitations in our study which need to be considered. The study was designed to reach adults with a landline phone, excluding individuals with only mobile or no phone at all. Given that in 2011 approximately 92.7% of German households had a landline connection, this could potentially have resulted in a bias toward individuals with a higher age and lower SES, among whom landline coverage was higher (48, 49). However, as the proportion of individuals who do not have a landline phone is rather small, we consider this bias to be of minor influence. This assumption is also supported by official statistics that show that in terms of the distribution of demographic and socioeconomic factors, the sample is similar to that of the total population in Germany (50). The inclusion criterion of high proficiency of the German language may have led to migrants being underrepresented in the study and to underestimating the differences between both population groups. The data we use were collected in 2009/2010 and are therefore slightly dated. Although studies on disparities between migrants and non-migrants with respect to other preventive services did not identify significant variation over time (51), investigations based on more recent data need to examine whether this is also true for dental prevention. Our data are based on self-report. Given that the time frame the question on the utilization of dental checkups referred to is rather small (12 months), we do not consider a recall bias to have distorted our findings. We also consider self-reported information on demographic and socioeconomic factors to be valid given that their distribution in our sample is similar to that of the total population in Germany (50). While we were able to take into account some enabling and predisposing factors, need factors such as the perceptions of health and illness and the respondent's appraisal of the necessity to use dental health care could not be considered as these information were not available in the secondary data set we used. The Andersen model had been shown to provide a valuable framework for the study of the utilization of health care in different settings and among different population groups. Using this framework (13), future studies should also examine personal health practices as well as barriers migrants experience in the dental health care system and that need to be considered in order to implement patient-oriented services and to reduce disparities in access to dental care.

ETHICS STATEMENT

The survey data collected by the Robert Koch Institute fulfill all necessary requirements and guidelines of the Federal data protection act. The survey was voluntary, anonymous and did not include experiments. Therefore, no further ethical approval was necessary.

AUTHOR CONTRIBUTIONS

PB, FE, and DW developed the concept and design of the study. PB performed the statistical analysis, interpreted the findings, and drafted the manuscript. FE and DW helped with the statistical analysis and data interpretation. All the authors read and approved the final manuscript.

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Medicaid Adult Dental Benefit Impact on Dental Utilization: A University Clinic Setting

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Introduction: In 2014, the state of Colorado initiated new dental coverage benefits for adults in the Colorado Medicaid program. The goal of this study was to investigate the utilization and impact of this new dental coverage at the University of Colorado School of Dental Medicine. The utilization of dental services delivered and the numbers of patients in this program were compared before and after the implementation of the benefit.

Materials and methods: This retrospective study compared the utilization of services provided 2 years prior and 2 years after the Medicaid adult benefit was made available. Through the University of Colorado School of Dental Medicine (CU-SODM) electronic dental record, all adult Medicaid dental patients' (ages 21+) charts were extracted for zip code, CDT dental procedure codes, with a focus on tooth extraction compared to tooth saving procedures. Graphical analysis and Pearson's chi-squared tests were applied to assess the statistical significance of procedure utilization changes over time.

Results: After implementation of the Medicaid adult benefit, the number of patients seen at the school under this program increased by a factor of 4.5. The geographic range (zip code) increased with some patients coming from further distances to receive dental care. The number of patients from local zip codes increased by as much as 235%. There was a 51% increase in tooth saving procedures, which was statistically significant ($P = 0.0013$). Additionally, there was a 22% decrease in extractions, while not statistically significant ($P = 0.0992$), a downward trend was clear.

Discussion: The focus was on the utilization of Medicaid adult benefits at the dental school, which was only a small proportion of the state-wide Medicaid population. Therefore, these data are not generalizable for statewide assessments of the program. However, based on the findings at the school clinics, more adult patients utilized the benefits; and chose to receive more tooth saving procedures and less extractions after implementation of the Medicaid adult benefit. This Medicaid study conducted at the CU-SODM 2 years after the adult dental coverage can be used as a baseline for future studies.

Keywords: adult Medicaid dental benefit, services, utilization, dental extraction, tooth saving procedures, University Dental School, Colorado

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INTRODUCTION

The Medicaid dental benefit is one of the few options for low-income adults seeking oral healthcare. Unfortunately, states are inconsistent in what benefits are provided for adult patients. Forty-seven states offer some benefits, but only 15 states offer comprehensive oral care. The adult dental benefits vary greatly between the other states with no minimum requirements for adult dental coverage mandated by the federal government. In addition, the Medicaid benefits are rapidly changing as a function of the economy and regulations. This makes it difficult for many patients to pursue consistent dental care (1, 2).

Several studies have found that without the Medicaid dental benefits, adults are left to seek care in the emergency department (ED) (3). In California, the elimination of dental benefits for Medicaid adult enrollees led to an immediate and significant increase in dental ED visits by Medicaid-enrolled adults (4). Similarly, the elimination of adult Medicaid dental benefits in Oregon in 2003 resulted in an increase in dental-related ED use as well as an increase in the incidence of unmet oral health needs among adult beneficiaries (5).

Conversely, a national analysis found that providing dental benefits may: (1) increase a patient's likelihood of visiting a dentist within the past 6 months; (2) reduce the likelihood of patients reporting dental needs not being met due to costs; and (3) reduce the likelihood of negative oral health outcomes (6). The advent of the Colorado Medicaid adult coverage in 2014 may have beneficial outcomes that need to be studied.

In 2014, Colorado decided to expand Medicaid under The Patient Protection and Affordable Care Act. Additionally, Colorado added a Medicaid Adult dental benefit for adults ages 21 and over. This new dental benefit provides eligible Medicaid members up to $1,000 in comprehensive dental services per fiscal year. The new benefit covers basic preventative dental exams, diagnostic and restorative dental services, extractions, root canals, crowns, partial dentures, complete dentures, periodontal scaling, root planning, and other procedures (7). Previously, Colorado adults received Medicaid coverage for only emergency dental conditions. Now that Medicaid in Colorado includes this limited adult dental benefit there are now hundreds of thousands of adults expected to seek dental benefits for the first time (8). This study focuses on the effect of the expansion of the Medicaid dental benefits for the adult population and not on various important demographic parameters such as race or ethnicity because the Medicaid expansion was solely based on age. The impact of the new adult Medicaid dental benefit in Colorado is a topic of interest.

Prior research in Colorado compared dental services utilization among the Medicaid population in the state before and after adding the new dental benefit to Medicaid plans. The study found that use of dental services increased after health reform (unpublished study). However, the study was limited to 1 year before and after adding dental benefits. Because the adult dental benefit was new, there were expected challenges in benefit design and administration, notifying people of the new benefit, and recruiting providers.

The current study builds upon the previous research and examines the impact of the Colorado Medicaid policy changes over the period of time 2 years prior through 2 years after the addition of the Medicaid adult dental benefit. Further, this study will focus on the population seen at the University of Colorado School of Dental Medicine (CU-SODM), which no other study has done before.

Our research question was "In the Medicaid adult population seen at the University of Colorado, School of Dental Medicine, what is the effect of the new Medicaid adult benefit on the numbers of patients and types of services utilized, compared before and after the implementation of the benefit?"

MATERIALS AND METHODS

This was a retrospective study where patient electronic dental records were examined for patient demographics, zip codes, and dental procedures delivered during the fiscal years (FYs) 2 years before and after the dental benefit. FY2013 and FY2014 are defined as pre-benefit and FY2015 and FY2016 are defined as post-benefit. This study was approved by the Colorado Multiple Institutional Review Board (COMIRB) #16-1156 as Not Human Research.

Through the University of Colorado School of Dental Medicine (CU-SODM) electronic dental record, all adult Medicaid dental patients' (ages 21+) charts were extracted for CDT dental procedure codes, with a focus on tooth extraction compared to tooth saving procedures.

Reporting of numbers of patients who live in specific zip codes was restricted to those who had a population of 20 or greater who came to the *School* for dental care. Those zip codes where numbers of patients were between 1 and 19 who came to the *School* for dental care were reported with an asterisk. This was done to assure patient anonymity.

Table 1 includes all the procedure codes used in this study. For the purpose of our study, restorative procedures, periodontal treatment, and endodontic treatment were categorized together as tooth saving procedures. The percentage of received dental services was normalized by dividing the number of specific procedures by the total number of procedures completed in that fiscal year.

TABLE 1 | CDT procedure codes used in this study.

Prevention	Periodontal	Fluoride treatment	Restorative	Endodontics	Pros-complete	Pros-partial	Bridges	Extractions
1,110	4,341	1,206	2,140–2,394	3,310–3,330	5,110	5,211–5,214	6,211–6,791	7,140
	4,342				5,120	5,221–5,224		7,210–7,250
	4,355				5,130	5,281		
	4,910				5,140	5,820		
					5,810	5,821		
					5,811			

Graphical analysis and Pearson's chi-squared tests of the percent of received procedures were applied to assess statistical significance over time (9). These data are categorical; therefore, we did not average the number of procedures received. Pearson's chi-squared tests were used to evaluate the statistical significance of the changes in procedure utilization over the 4-year period of our study. The statistical analyses were performed using each year of the study to assess significance of the changes year to year. FY2013 was compared to FY2016 and FY2014 was compared to FY2015. This approach evaluates both the end points and the interim changes over the 4 years of our study. Additionally, zip code mapping was conducted to evaluate any changes in the service area of where the patients live over the years.

RESULTS

Number of Adult Medicaid Patients Seen by Fiscal Year

The total number of adult Medicaid patients seen at the CU-SODM increased from 632 in FY2013 to 2,843 in FY2016, an increase of almost 350%, from FY2013 to FY2016. The population growth in the 26 zip codes where the greatest number of patients live increased from 954,953 in FY2013 to 1,012,334 in FY2016, an increase of 6.0% [data extracted from Ref. (10, 11)].

The relative percentage of the demographics of the adult Medicaid patients remained consistent pre-benefit and post-benefit, with the majority of patients being women and non-Hispanic (**Figure 1**). This is also reflective of the overall Medicaid population in the *School's* traditional service area within the state. The numbers of individuals seeking dental care in this program increased for all of the demographic categories. Additionally, the racial make-up of the study population also remains consistent pre- and post-benefit, with the majority of patients being non-Hispanic white (**Figure 1**).

Geographic Profile by Zip Code

Over the four FYs, the geographic service range increased with a larger number of patients coming from zip codes that are further away to receive dental care. The biggest increases occurred in zip codes that were closer to the school. Additionally, access to care was also expanded within our community. There was an increase from 91 patients in FY13 to 295 patients in FY16, a 3.3-fold increase, which came from the two zip codes immediately surrounding the *School* (80011 and 80010) with similar increases in patients from adjacent zip codes as shown in **Figures 2** and **3**. The number of Medicaid enrolled adults by zip code is not available for Colorado. However, if one presumes that the number of Medicaid enrolled adults in the two counties that include these two zip codes is indicative, then a perspective of the impact of the expansion of the Medicaid benefits enacted for FY2013 may be obtained. The number of Medicaid enrolled adults increased dramatically increased

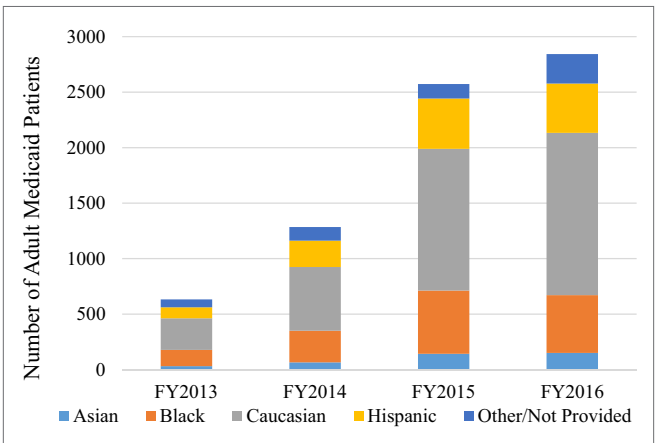

FIGURE 1 | Number of adult Medicaid patients seen and demographic breakdown by Fiscal Year 2013–2016.

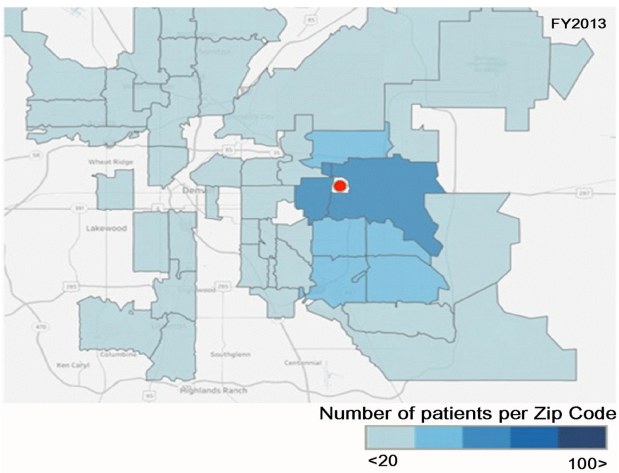

FIGURE 2 | The number of Medicaid adult patients by zip code for FY2013. Red circle is the location of the CU-SODM.

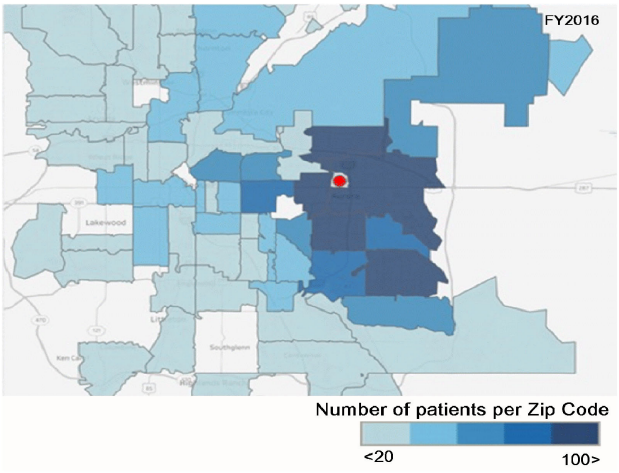

FIGURE 3 | The number of Medicaid adult patients by zip code for FY2016. Red circle is the location of the CU-SODM.

TABLE 2 | Proportion of procedures and total number of procedures delivered by year.

Procedure delivered	FY2013	FY2014	FY2015	FY2016
Prevention (%)	10.22	8.96	6.42	8.19
Fluoride (%)	5.05	4.11	1.81	3.64
Tooth saving procedures (Perio, Rest, Endo) (%)	30.17	40.23	40.22	45.63
Extractions (%)	47.60	44.68	47.84	37.20
Pros and bridges (%)	6.97	2.02	3.71	5.34
No. procedures delivered (%)	832	1,484	6,353	7,436

TABLE 3 | Pearson's chi-squared statistical analyses of the change in tooth saving procedures over time: Perio + Restorative + Endo.

FY2013 vs. FY2016		FY2014 vs. FY2015	
Before	30.2	Before	40.2
After	45.6	After	40.2
Change	15.5	Change	0.0

Crosstabulation		Tooth saving: Before	Tooth saving: After	Total
FY2013 vs. FY2016	Count	30.2	45.6	75.8
	Exp count	43.0	32.8	75.8
	Chi²	3.840	5.041	8.88
	Std. Resid	−1.960	2.245	
FY2014 vs. FY2015	Count	40.2	40.2	80.5
	Exp count	45.7	34.8	80.5
	Chi²	0.647	0.849	1.50
	Std. Resid	−0.804	0.922	
Total count	Count	70.4	85.9	156.3
	Exp count	88.7	67.6	156.3
	% within category	45.1	54.9	100.0
	Chi²	10.377		
	Deg freedom	1		
	P	0.00127565		

from 24,689 (FY2013) to 62,676 (FY2016) in Adams County (zip code 80011) and 25,839 (FY2013) to 66,382 (FY2016) in Arapahoe County (zip code 80010). The growth in enrolled adults into Medicaid increased by a factor of 2.5 from FY2013 to FY2016 [data extracted from Ref. (12)].

Utilization of Services

In this study, over the period from pre-benefit to post-benefit, there was an increase in utilization upon the availability of the benefits as shown in **Table 2**. Pearson's chi-squared tests were utilized to assess significance in the change of tooth saving procedures and tooth extraction procedures over time. **Tables 3** and **4** show these chi-squared tests. There was a 51% increase in tooth saving procedures delivered, which was statistically significant ($P = 0.0013$). Additionally, there was a 22% decrease in extraction procedures performed, while not statistically significant ($P = 0.0992$), the downward trend was clear as shown in **Figure 4**. The percent of tooth saving procedures increased in all age groups and ethnicities (**Figure 5**). The percent of extraction procedures decreased in all, but the 45–65 age groups (**Figure 6**).

TABLE 4 | Pearson's chi-squared statistical analyses of the change in tooth extraction procedures over time: ADA codes 7140 + 7210 + 7250.

FY2013 vs. FY2016		FY2014 vs. FY2015	
Before	47.6	Before	44.68
After	37.2	After	47.84
Change	−10.4	Change	3.16

Crosstabulation		Extractions: Before	Extractions: After	Total
FY2013 vs. FY2016	Count	47.6	37.2	84.8
	Exp count	48.1	36.7	84.8
	Chi²	0.006	0.008	0.01
	Std. Resid	−0.077	0.088	
FY2014 vs. FY2015	Count	44.68	47.84	92.52
	Exp count	52.5	40.0	92.52
	Chi²	1.169	1.535	2.70
	Std. Resid	−1.081	1.239	
Total count	Count	92.28	85.04	177.32
	Exp count	100.7	76.7	177.32
	% within category	52.0	48.0	100.0
	Chi²	2.718		
	Deg freedom	1		
	P	0.09920717		

DISCUSSION

The aim of this study was to compare dental services utilization at the University of Colorado School of Dental Medicine (CU-SODM) 2 years before and after the advent of the new adult Medicaid dental benefit to Medicaid plans, with a focus on tooth saving procedures vs. extractions. The COMIRB restriction to protect patient privacy was that this study would not provide the number of patients from any zip code where less than 20 patients came to the *University* for dental care resulted in patient counts from 26 zip codes. There was a dramatic increase in the number of adult Medicaid patients seen in the CU-SODM dental clinics over the 2 years since the inception of the adult Medicaid benefit (**Figure 1**). The 350% increase in the number of Medicaid patients seen at the *University* is far greater than the 6.0% increase in the general population of the 26 zip codes over the same period of time. This shows that the expansion of the adult Medicaid dental benefit in Colorado is being utilized by a larger percentage of the population than prior to the implementation. This is consistent with similar observations made in states such as Massachusetts when they started their expanded dental care program (13) as well as Iowa and Washington states where there has been a large increase in adults receiving a dental service since the inception of their respective adult Medicaid based programs (14).

In general, the most frequent two procedures received as the CU-SODM were tooth saving procedures and extractions, compared to preventative procedures, fluoride treatment and prosthodontic procedures (**Figure 4**; **Table 2**). Compared to the pre-benefit period, patients chose to receive more tooth saving procedures and less extractions. Patients in all but the 45–65 age groups reduced the amount of extraction procedures (**Figure 5**). This finding could be due to pent-up demand in patients of that age group who may have delayed any dental treatment until the adult Medicaid benefit became available to them.

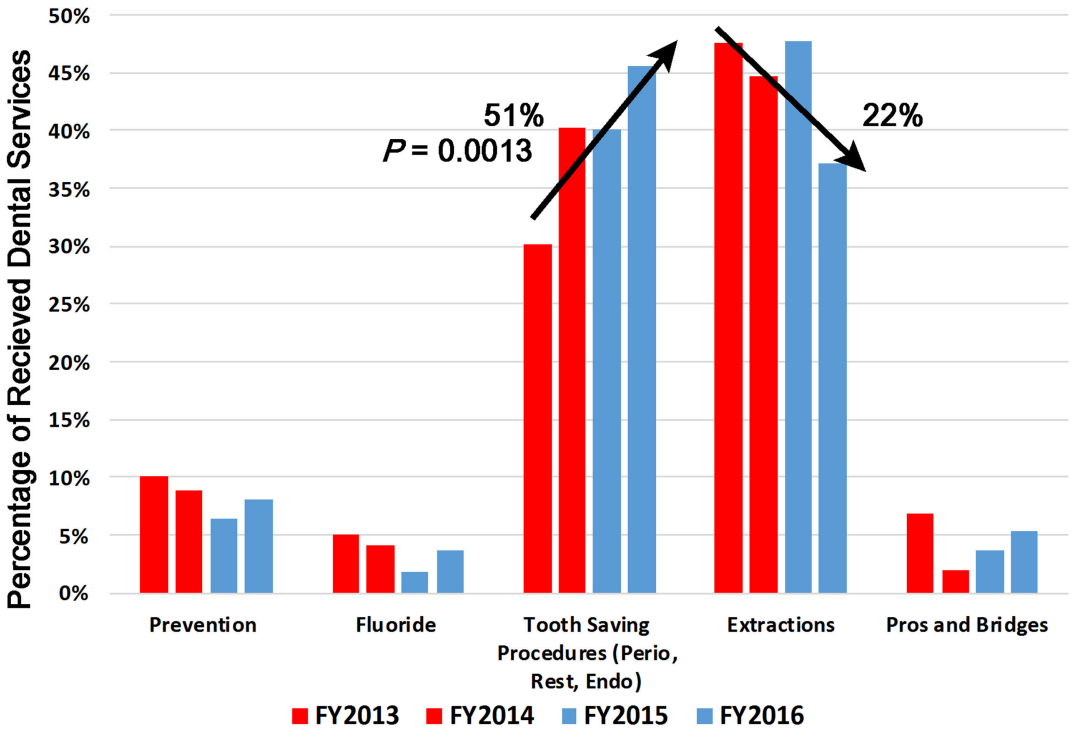

FIGURE 4 | Percentage of received dental services by procedure type for FY2013–2016.

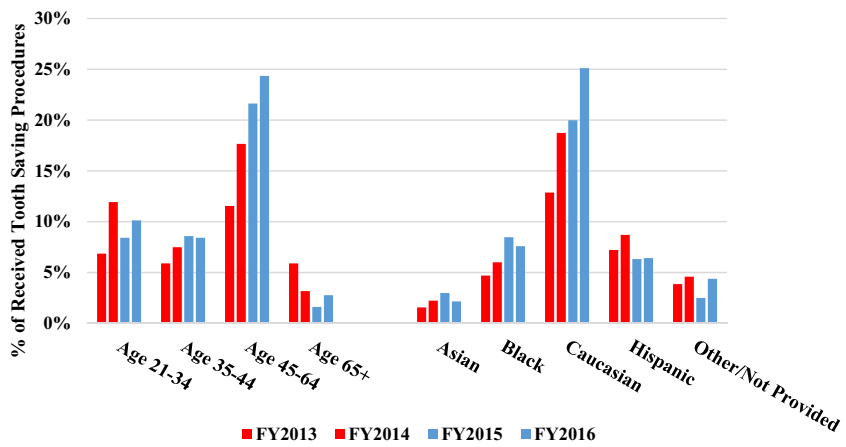

FIGURE 5 | Demographics of tooth saving procedures by age groups and ethnicity for FY2013–2016.

Our findings show early signs of adult patients making choices to save their teeth upon availability of the adult Medicaid benefits. These findings can be linked to the fact that there are differences in dental utilization based on insurance types (15). For instance, tooth extractions are the most likely option for the low-income population with no or emergency-only benefits. A comparative study in Iowa reported that those with public insurance were four times more likely to have had a tooth extracted than those with private insurance (16). However, multiple studies show that improved oral health is associated with a decrease in chronic disease risk; and tooth retention in particular may extend lifespan (17, 18). A recent critical review found evidence that retention of teeth is associated with better oral health-related quality of life (19). Furthermore, this study highlights the importance of the Medicaid adult dental benefit on various types of dental treatments that may predict better overall health outcomes and quality of life for patients.

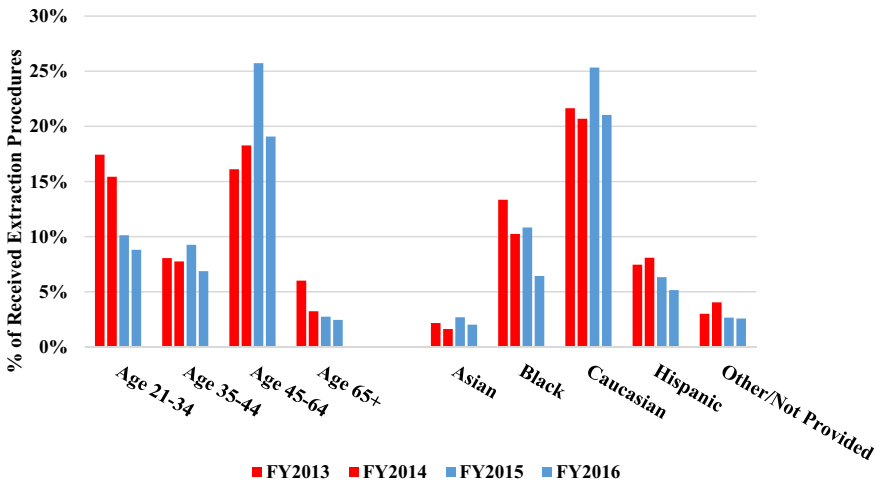

FIGURE 6 | Demographics of extractions by age groups and ethnicity for FY2013–2016.

This is the first adult dental Medicaid study conducted at the CU-SODM and can be used as a baseline for future studies. It is important to acknowledge that our data are not readily generalizable to the state-wide adult Medicaid population. Compared to the state, the dental school clinics provided services to a small proportion of this population. Additionally, the university clinic setting is a unique teaching environment and is different than what is seen at general health-care clinics. For example, there are differences in the types of procedures and treatment planning, and patients are not seen over a long period of time.

Given the importance of health-care reform and the changes to Medicaid benefits on a frequent and irregular basis, more studies are needed to track how the Medicaid program is improving oral health. This study focused on tooth saving vs. tooth extraction choices made by adults and their caregivers in this study. Further studies should evaluate the impact of the availability of adult Medicaid dental benefits on other important demographic classes such race, gender to ethnicity to assess the penetration of the program to underserved populations around the *Dental School*. Our study will be shared with stakeholders throughout the state including Colorado's Medicaid Program—Health First Colorado—and other dental schools around the nation to encourage a statewide and national analysis done following our methods.

Because oral health is a critical component of general health, future research should evaluate individual-level data and analyze the impact of dental benefits on other health outcomes such as chronic diseases.

CONCLUSION

Our findings at the University of Colorado School of Dental Medicine provide evidence that offering adult Medicaid dental benefits can improve dental care access and use of comprehensive services. This study highlights the importance of the Medicaid adult dental benefit on various types of dental treatments that may predict better overall health outcomes and quality of life for patients. The adult Medicaid benefit, dental school, and dental students are improving the lives of our community around us.

AUTHOR CONTRIBUTIONS

LD: study design, data evaluation, writer. TT: data evaluation, writer. DB: study design, data evaluation, writer. CC: study design, data evaluation, writer.

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frontiers in Public Health

REVIEW
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New Zealand's School Dental Service over the Decades: Its Response to Social, Political, and Economic Influences, and the Effect on Oral Health Inequalities

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New Zealand's School Dental Service (SDS) was founded in 1921, partly as a response to the "appalling" state of children's teeth, but also at a time when social policy became centered on children's health and welfare. Referring to the Commission on Social Determinants of Health (CSDH) conceptual framework, this review reflects upon how SDS policy evolved in response to contemporary constraints, challenges, and opportunities and, in turn, affected oral health. Although the SDS played a crucial role in improving oral health for New Zealanders overall and, in particular, children, challenges in addressing oral health inequalities remain to this day.

Supported by New Zealand's Welfare State policies, the SDS expanded over several decades. Economic depression, war, and the "baby boom" affected its growth to some extent but, by 1976, all primary-aged children and most preschoolers were under its care. Despite SDS care, and the introduction of water fluoridation in the 1950s, oral health surveys in the 1970s observed that New Zealand children had heavily-filled teeth, and that adults lost their teeth early. Changes to SDS preventive and restorative practices reduced the average number of fillings per child by the early 1980s, but statistics then revealed substantial inequalities in child oral health, with Māori and Pacific Island children faring worse than other children.

In the 1990s, New Zealand underwent a series of major structural "reforms," including changes to the health system and a degree of withdrawal of the Welfare State. As a result, children's oral health deteriorated and inequalities not only persisted but also widened. By the beginning of the new millennium, reviews of the SDS noted that, as well as worsening oral health, equipment and facilities were run-down and the workforce was aging. In 2006, the New Zealand Government invested in a "reorientation" of the SDS to a Community Oral Health Service (COHS), focusing on prevention. Ten years on, initial evaluations of the COHS appear to be mostly positive, but oral health inequalities persevere. Innovative strategies at COHS level may improve oral health but inequalities will only be overcome by the implementation of policies that address the wider social determinants of health.

Keywords: New Zealand School Dental Service, Community Oral Health Service, dental caries, oral health inequalities, dental nurse, dental therapist, oral health therapist, dental therapy

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INTRODUCTION

New Zealand's School Dental Service (SDS) was established in the early twentieth century, at a time when social policy became centered on the health and welfare of children to better ensure the future success of the "race, nation and Empire." As such, the SDS has been part of the structure of New Zealand's oral health care system for close to 100 years and has had a formative influence on the lives of nearly all New Zealanders. Since its establishment in 1921, the SDS has had continued political support from successive Governments. This has focused on policies to improve the quality of care and interventions, access to care, and upskilling the workforce. Children's oral health has improved considerably; however, oral health inequalities exist, with worse oral health outcomes experienced by Māori and Pacific Island children and adolescents, and children and adolescents living in areas of higher socioeconomic deprivation (1). This historical review focuses on key periods in the development of the SDS, as influenced by social, economic, and political factors, and critically examines the Service's efforts to both improve oral health and, more recently, to reduce inequalities in oral health.

When examining the history of the SDS, it becomes clear that the socioeconomic-political context has had an impact on the service, and the inequities and inequalities in oral health that still exist. This broad term (socioeconomic-political) refers to the spectrum of factors in society that cannot be measured directly at the individual level. The Commission on Social Determinants of Health framework (**Figure 1**) shows how social, economic, and political mechanisms give rise to a set of socioeconomic positions, whereby populations are stratified according to income, education, occupation, gender, race/ethnicity, and other factors. These socioeconomic positions in turn shape specific determinants of health status (intermediary determinants) reflective of people's place within social hierarchies. Based on their respective social status, individuals experience differences in exposure and vulnerability to health-compromising conditions (2).

The CSDH framework differs from many previous models in that it conceptualizes the health system itself as a social determinant of health (2). The SDS [now known as the Community Oral Health Service (COHS)] has been part of the New Zealand health system for almost a century and has developed over time as a result of the ever-changing social, political, and economic environment, thus impacting on oral health status in general and inequities in oral health. By utilizing the CSDH framework, we can explore the structural and social determinants that have impacted on the delivery of a service whose primary role was to improve the health and welfare of New Zealand children.

ESTABLISHING A DENTAL SERVICE FOR CHILDREN

At the first New Zealand Dental Association (NZDA) conference in 1905, F.W. Thompson, a well-known dentist, presented a paper entitled "the Teeth of our Children." After examining the children at a Christchurch primary school, Thompson claimed that 98% of children did not receive the dental care they deserved. The majority had decayed teeth, many of which were beyond saving, and very few had had any dental treatment. Thompson's paper was well-received among NZDA members and came to the attention of Parliament, where it was printed and circulated as a parliamentary paper (3). However, awareness of the existence of an issue, such as children's poor oral health, is no guarantee that

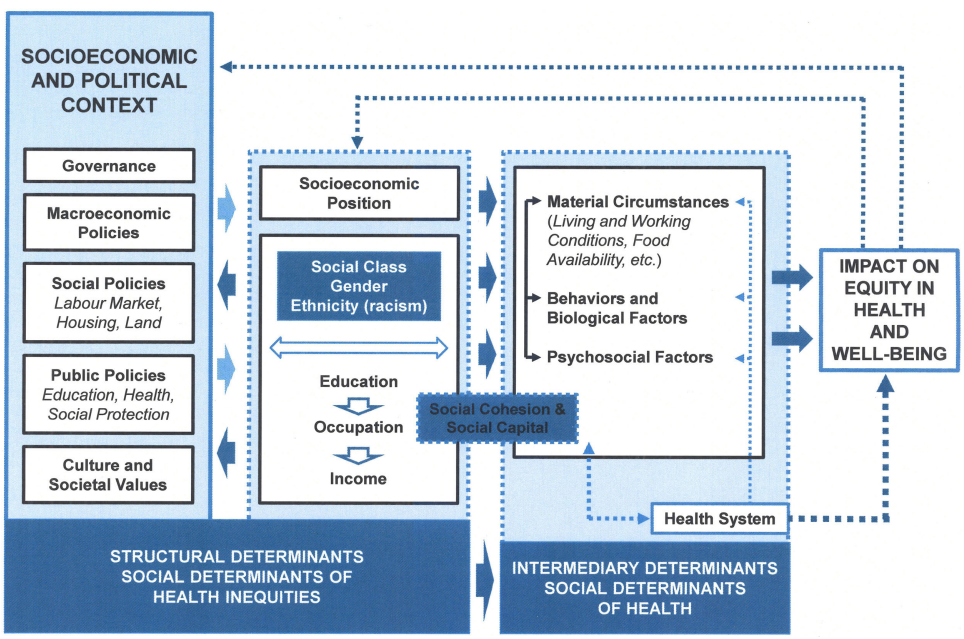

FIGURE 1 | The Commission on Social Determinants of Health conceptual framework (2).

an item will be placed on a Government's agenda. The issue needs to be considered a legitimate one in which the Government feels it has a right to intervene, has the necessary technology, resources, money and personnel available, the infrastructure required, and the support of the public (4). Policy development usually occurs as the result of a multitude of factors that may include situational, structural, cultural, and environmental factors (5,6). Furthermore, the CSDH framework notes that the socioeconomic and political context has a "powerful influence" on patterns of social stratification which, in turn, determine health status. Previous work on the determinants of health has paid little attention to the political context, however. The social determinants of health are shaped by Government policies; decisions made in the political context will impact on health and health inequalities but are themselves driven by a variety of political, economic, and social forces (2). In the case of the SDS, its establishment, and the form it took, was very much influenced by not only the political conditions of the era but also social and economic factors.

Lobbying by dentists and the NZDA for a state dental service for children came at a time when New Zealand's Liberal Government (1890–1911) was already engaged in an extensive program of social reform. Its role in the economy and provision of public welfare were expanding rapidly (7), and New Zealand was developing a reputation as somewhat of a "social laboratory" for the world (8). In terms of health, a Department of Public Health was established in 1900, and once progress had been made addressing issues such as sanitation, clean drinking water, vaccination, and tuberculosis, attention turned to the issue of children's health (9). Concerns about national efficiency and racial fitness compelled the Government to intervene where children's health was concerned. Children were now regarded as "social capital;" investing in their health would ensure the race, nation, and Empire of its continued success (10, 11). As a result, social policy became centered on child health and welfare. Accordingly, several new health initiatives emerged, including St. Helen Maternity Hospitals (1904), the Society for the Protection of Mothers and Babies (or Plunket as it became known) (1907), the School Medical Service (1912), Physical Education in schools (1912), Children's Health Camps (1919) (**Figure 2**), and eventually the SDS (1921).

Dentists also harbored concerns about national efficiency and the effect of poor oral health on general health; they and their medical counterparts attributed many childhood illnesses to poor oral health (14–16). However, while NZDA members had a true "crusading zeal" to improve children's teeth, their campaign for a state-funded dental service for children was also political and tied up in their move toward professionalism (17). By advocating for a state-funded service for children, staffed by registered, preferably university-educated dentists, the NZDA hoped to close that corner of the market to unregistered, unqualified "mechanical dentists" whose patient group consisted mainly of the poor, Māori, and children. Lobbying for a service for children would also, hopefully, enhance their professional status in the eyes of both the Government and the public (17, 18).

While the NZDA continued to lobby and meet with Ministers of Parliament, there was little progress on implementing any type of service before the outbreak of the First World War in 1914. The war, however, drew more attention to the appalling state of the nation's teeth (17). A high percentage of recruits were rejected for service due to their poor oral health and many others required extensive treatment to become "dentally fit." Many attributed this poor state of affairs to lack of attention to oral health in childhood (19). As a result, the NZDA turned their focus to the formation of the highly successful Dental Corps (17). Priorities were different now, and there was no money for a school service. Although their attention was now focused elsewhere, the NZDA continued to discuss schemes for children's dentistry for, as A.M. Carter rather melodramatically stated in his NZDA Presidential address of 1916 (20):

> …the war of the nations will end, and in our hearts we know Victory will be ours, but in the dental disease so rampant in our schools we have a more insidious foe, and one that has been far too long underestimated, and that is steadily sapping the vitality and lowering the stamina of our national life.

In 1917, Richmond Dunn, a NZDA member, suggested that a new profession of "dental nurse" be created. Employing female dental nurses would go some way to solving the problem of the shortage of dentists at that time but would also relieve dentists of the "child-work" that many of them found so "trying to the nerves." Dunn, however, believed that the dental nurse should have more of a preventive focus, and not merely be used to repair "the ravages of disease." New Zealand's Plunket nurses had been successful in offering advice and service to mothers and their babies, and a dental nurse might prove similarly effective in caring for children's teeth (21). Dunn's idea gained the support and a committee of NZDA members subsequently met with the Ministers of Public Health and Education to put forward its plan for a school-based dental service for children. However, the Ministers considered the cost prohibitive and that it was not possible to implement such a plan in wartime (17, 22, 23).

FIGURE 2 | Toothbrush drill at a Health Camp [Hocken Collections, Uare Taoka o Hākena, University of Otago Library (Archives Reference: AG-007-007-018/001)]. New Zealand's Children's Health Camps were founded in 1919 for primary-school-aged children who had health issues, such as malnutrition and tuberculosis (12). Nowadays, the Health Camps are more likely to cater for children needing help with social skills, "time out," or respite care (13).

After the war, the NZDA tried again, this time supported by several powerful allies in putting its case to the acting Prime Minister, the acting Minister of Finance, and the Ministers for Public Health and Education. The deputation was well-received, particularly because the Ministers appreciated the NZDA's "splendid work" during the war (24). After some initial delays, the Government appointed four school dentists in 1919 to form the basis of a school service, with control of the Service eventually passed to the newly established Dental Division of the Department of Health which was, in turn, responsible to a combined ministerial portfolio of Health and Education (17). Colonel (later Sir) Thomas Hunter was appointed Chief Dental Officer but resigned shortly after, when he learned that Government had failed to consult the NZDA over his appointment. This was a political move, reflecting the NZDA's desire to play a major role in policy. When Hunter eventually took up the role in late 1920, it was as the Director of the Division of Dental Hygiene within the Department of Health (17).

THE NEW ZEALAND SDS TAKES SHAPE

In April 1921, the first "draft" of dental nurses commenced training in a Department of Health course, based in Wellington, the nation's capital (**Figure 3**). Hunter had decided that 2 years' training would be enough time to train the nurses to treat children's teeth, mainly the "temporary" teeth. Dental nurses would be less expensive to employ and take less time and money to train than dentists. He also believed, no doubt influenced by stereotypical notions of women's work and social norms of the time, that women were "temperamentally and psychologically more suited than men to deal with and treat the ailments of very young children." Dental nurses were to be regarded as "auxiliaries," especially trained for treating children, rather than "half-trained" dentists (25). Furthermore, while dentists may have felt threatened by this new role, marriage and children would prevent dental nurses from setting up their own practices because women in New Zealand's Public Service had to stop working once they married (17, 25, 26).

FIGURE 3 | The extraction room, Training School, Wellington, 1922 [Archives New Zealand/Te Rua Mahara o te Kawanatanga, Wellington Office (Archives Reference: ABKI 667/1)]. Dental nurse trainees treated Wellington school children, with their oral health need being so great that an "extraction room" was set up. Two students each day would be assigned to the room and would spend the day extracting teeth.

Hunter was the driving force behind the SDS and was probably the most suitable person for the job at the time (17). He had served as President of the NZDA twice in its early years and had strongly supported the proposal for a dental service for children. Furthermore, during the war, he had been a very efficient Director of the Dental Corps (17). Hunter was passionate about his new role and committed to making a SDS, staffed by dental nurses, work. The model that Hunter developed, however, reflected the hierarchical power structures in health at the time. Doctors, usually white, middle-class, and male, ran the hospitals, and dentists from similar backgrounds would determine the direction the SDS took. The idea of a dental *nurse* would gain support from dentists, with the doctor/nurse relationship evoking ideas of a similar relationship between dentists and dental nurses. Nurses were expected to be obedient, disciplined and self-controlled, and had a place in paid employment but were no threat to men's public roles (27). Very little consultation took place over the form the SDS would take, other than with members of the NZDA, who were determined to shape policy and the direction the SDS took, thus also protecting their own professional aspirations. However, although the role of the dental nurse had been defined as subordinate to that of dentists, the training program had a scientific basis, more so than nursing curriculums of the time, in which doctors dictated the level of knowledge required by nurses. The first Director of the School was Richmond Dunn, had been a science teacher, and he based the dental nursing course on the Dental School curriculum (28).

On graduation, the dental nurses were sent to work in school and community clinics. Schools were initially expected to establish a clinic and fund its ongoing maintenance, while the Department of Health supplied the dental equipment and the dental nurse (28). Clinics were many and varied; while some nurses went to purpose-built clinics, others worked in school classrooms, staff rooms, community halls, hospital buildings, shelter shed, and even school porches (29). The conditions were difficult, as was the treatment the dental nurses undertook. The majority of early dental nurses described the children's teeth as "appalling" and "shocking" (30, 31). "They were incredible, those poor children with abscesses and the pain they must have endured… the extractions we had to make…" (30).

By the end of the decade, more children were under the care of the Service, and working conditions for dental nurses were improving, with most clinics now situated in buildings jointly designed for the purpose by the Departments of Health and Education (**Figure 4**) (32, 33). In 1928, the Minister of Health announced that the Service would need 300 dental nurses in order to treat all school children. As the Service at this point only had 74 dental nurses and eight dentists, this was a significant expansion and demonstrated the support of the Government for the SDS (9). Hunter, however, noted that for those children who were already under care, there was still a lot of recurrent treatment. In his opinion, parents were not ensuring good oral health practices

FIGURE 4 | "Double clinic"—the interior of the Napier dental clinic before the earthquake [Archives New Zealand/Te Rua Mahara o te Kawanatanga, Wellington Office (Archives Reference 672/1)]. The dental clinic was destroyed during the 1931 Napier earthquake. Fortunately, the dental nurses and their patients escaped with very little injury (34).

were being carried out at home and were placing "… the whole onus of caring for the teeth of their children on the State" (33).

DEPRESSION, WELFARE, AND WAR

During the 1930s and 1940s, both social and economic conditions, and resulting policy decisions played a major part in the further development of the SDS. In particular, two major international events impacted on the SDS's development, the first being the "Great Depression" and the second being World War II. While considered milder in New Zealand, the Depression, nonetheless, profoundly affected everyday life. The Government's response to the country's economic position was to appoint a "National Expenditure Commission" which recommended that the SDS not be allowed to expand further (28, 35). In the opinion of the Commission, there was an "…increasing tendency on the part of the community to look to the State for the provision of extra social services which had never in the past been regarded as the responsibility of the State." Services that the State could afford in more prosperous times would have to be reduced or discontinued and the Commission recommended that the SDS not take on any new dental nurse students (35). However, rather than exclude students entirely, the Service reduced its intake between 1931 and 1935 (28).

Fewer dental nurses meant that arrears in patient treatment accumulated rapidly (28). To counteract the shortage of dental nurses, the Department of Health made the unusual move for the times of re-employing some married dental nurses (36). The decision was also made to maintain the 6-monthly recall for children already under care, and only extend treatment to new enrollments once this was under control (28). Parents were now charged a levy of up to five shillings for their child's treatment and, once this was introduced, enrollments for care decreased to a certain extent. Parents could also apply for an exemption if they were unable to pay the fee and rising unemployment meant more exemptions were granted. For example, in 1934, of those enrolled for treatment at the training school clinic, approximately one-fifth did not have to pay (37, 38).

While the Commission made other recommendations, such as reducing the Government subsidy paid for schools to establish clinics, increasing the levy schools paid for their dental nurses, and even going as far as suggesting some dental nurses be dismissed, most of their recommendations were ignored (28, 35). This was most likely due to the fact that the Government was very aware that the SDS was valued by the public and calls for its expansion were increasing (28). This was somewhat of a political move on the part of the Government; however, although improving, children's oral health was far from perfect and further downsizing the SDS would have been severely detrimental.

By 1935, the worst of the Depression was over and the SDS was able to once more increase its student intake. The SDS was to benefit further when the new Labour Government was elected at the end of 1935. By this stage, the service had approximately 50% of children aged up to 10 years under treatment but the Government wanted all children to be receiving dental care by 1940. Plans were put in place to double the number of dental nurses and to build a new training school (28). The intake of more students, however, brought no immediate relief to those working in the field. The shortage of staff placed limitations on how quickly the service could expand, and the closing of schools for several weeks due to a polio epidemic, placed further strain on the patient recall system (39). Despite the difficulties, figures documented toward the end of the 1930s show a steady increase in the numbers of dental nurses.[1]

In 1938, the Government introduced the Social Security Act, with hospital treatment, medicines, and general practitioner (GP) consultations all intended to be free of charge. The New Zealand Branch of the British Medical Association (BMA) successfully argued, however, against free GP visits, resulting in a part-subsidy/part-private funding arrangement (17). The Government had also consulted the NZDA on whether free dental care beyond primary school children should be included in the scheme. Discussion continued into the 1940s, with decisions being delayed somewhat due to the Minister of Health's preoccupation with the BMA (17). John Llewellyn Saunders, by then Director of the Division of Dental Hygiene, further complicated matters, when he suggested that dental nurses could treat adolescents and adults (40). This did not go down well with the NZDA, who reminded Saunders that while the Government had previously approved extension of dental care, it was to adolescents only (28).

The advent of war meant further delays to any decision about what form any possible state-funded dental care would take. For the SDS, war brought the slowing down of its clinic-building program due to the wartime control of labor and materials (41). Staff shortages were also an issue, with a higher loss of dental nurses through marriage during wartime. Although Saunders frequently lamented that war was slowing down plans for the SDS's

[1] According to the Annual Reports of the Director-General of Health in the *Appendices to the Journals of the House of Representatives* H-31, 1931–1945.

complete coverage of schools, good progress was made during this time. Despite the number of dental nurses only increasing slowly, the children brought under SDS care more than doubled (see text footnote 1). Dental nurses also started treating the older primary school classes, children aged 11–13 years, but could only accept these children after they had provided treatment for all preschoolers presenting for care. This was partly done to appease the NZDA, who were not only concerned about the amount of restorative work still being carried out and what they believed to be a lack of attention to dental health education and preschool oral health (42), but were also most likely also concerned about competition for patients, with an expanding SDS rapidly gaining favor with the public. The Government would also demonstrate its continuing commitment to the service and dental care for children by opening a new dental nurse training school in Wellington in 1940 (**Figure 5**).

ORAL HEALTH IMPROVEMENTS AND INEQUALITIES

Policy decisions made by successive Governments determined the direction the SDS took and, in turn, impacted on children's oral health. When the SDS was established, only children at state-funded schools were eligible to enroll in the SDS, and SDS policy dictated that dental nurses were to treat children in the junior classes first, then recall them regularly for care. There were issues with this policy; local communities were providing financial support for clinics but not all their children were being treated. Parents found it difficult to understand why their younger children could have free care but not their older ones (28). However, attempting to treat all the children would have meant the dental nurses would be restricted to "relief of pain" work only and, thus, be unable to bring children back for regular recalls. Furthermore, there would be no opportunities for preventive care or dental health education.

FIGURE 5 | The Dominion School for Dental Nurses, Willis Street, Wellington, 1940 [Archives New Zealand/Te Rua Mahara o te Kawanatanga, Wellington Office (Archives Reference: ABKI 667/3)]. "In many ways its imposing structure made it appear like a temple of the welfare state. Solid, large and built to allow the most efficient use of space, it symbolised in architectural form the ideal of a benevolent, centralised State social service" (17).

The progress of the SDS in treating dental caries was measured by the extraction-to-filling ratio. Initially, due to the very poor oral health of the children, dental nurses were extracting hundreds of teeth (43). A dental nurse from Dunedin, in later years, commented of her early experience in the SDS: "I did 1700 extractions in a year. Sometimes the pus would run down over your fingers. You've no idea what the mouths were like" (44). The extraction to filling ratio, however, improved over the SDS's first decade, showing an almost fivefold decrease (**Table 1**).

Many Māori children attended "Native Schools" and could not initially enroll for care in the SDS but the SDS had selected four Māori students for training between 1925 and 1926 so that they could be "…trained for work amongst the Native children" (45). This indicated an awareness of a need for dental care for Māori children; Māori nurses were employed to care for Māori, particularly those in isolated areas and the intention may have been to do the same for oral health. By 1929, however, all schools (including denominational and private schools) were able to establish their own dental clinics (28).

At first, Māori children had better teeth than their European counterparts. The Department of Health reported in 1924 that European children had, on average, twice as many filled teeth as Māori children (46). The dental nurses also noticed that Māori children often had better teeth, with one commenting of the Māori children in Rotorua: "I have never seen such beautiful teeth… I can't remember extracting a tooth from a Māori child" (47). In 1931, the Department of Health Annual Reports began to distinguish between the oral health of Māori and "White" children (48). These also confirmed that Māori children initially had better teeth (48–50). Their oral health, however, appeared to deteriorate rapidly when they adopted more "westernised" diets. By the mid-1930s, the Dental Officer for the Native Schools, Dr. Luke Rangi, observed that there was now very little difference between Māori and non-Māori teeth. "Both were equally bad." He noted, however, that Māori children who lived further away from the "white centres of population" still had better teeth (38).

By the late 1930s, despite the "efforts" of dental nurses, school medical officers, district health nurses, and teachers, very few Native Schools had access to dental clinics. The "indigent Māori parent" and "apathy of the Māori people towards dental treatment" were considered to be the main obstacles to care (51). While Māori were stigmatized as not caring about their oral health by those in power in the Department of Health, in

TABLE 1 | Number of extractions per 100 fillings (1921–1931) (37).

Year	Extractions per 100 fillings
1921–1922	114.5
1922–1923	103.3
1923–1924	79.7
1924–1925	72.6
1925–1926	67.2
1926–1927	62.8
1927–1928	56.3
1928–1929	52.3
1929–1930	37.2
1930–1931	25.5

reality, Department decisions about where dental clinics were established meant that few Native Schools were located in areas near the growing network of dental clinics in the 1930s (52).

Access to health services for all New Zealanders in the early decades of the twentieth century was generally determined by their availability and affordability; however, services for Māori were further limited by cultural, bureaucratic, and geographical difficulties. In terms of oral health, Māori communities were less likely to have the financial means to establish clinics which also included paying for the dental nurse's accommodation, non-technical equipment, cleaning, lighting, and a levy of £30 per dental nurse per year (52). Māori children who received no care at all quite possibly would have had worse oral health than those who were seen by the Dental Officer for Māori. The School Medical Service also did not have the resources or staffing to include all Native Schools in its service and District Health Nurses were in short supply. It often fell to the teachers at the Native Schools to offer health advice and care to Māori, including most likely dental advice. While differential access to healthcare could be considered a drawback of a developing public health service, nowadays this would be considered a form of institutionalized racism and a major factor behind health inequities. By the late 1930s, however, the passing of the Social Security Act (1938) and policies supporting universal access to health care improved Māori access to services. By 1941, the Government had abolished the levy school committees paid for their dental nurses, instead paying the committees an annual levy to cover running costs and encourage further development of dental clinics. In addition, parents no longer had to pay a fee for dental care as was the case during the Depression (53). The CSDH framework notes that population health is partly dependent on the type of welfare regime, with social democratic countries exhibiting significantly better population health status (2). In New Zealand, progress in Māori general health was facilitated by the policies and programs of the Welfare State (54). Although there are no specific statistics for oral health, it is likely that Māori oral health began to improve with better access to care. However, while the gap in health status between Māori and non-Māori narrowed during these years (as measured by mortality and morbidity); it was still very evident (54).

Overall, over this period, oral health continued to improve for children in the care of the SDS, with the extraction-to-filling ratio decreasing to 6.3 extractions per 100 fillings by the end of the war (55). Unfortunately, dental examinations of men entering the armed forces during World War II revealed that adult oral health was still very poor. Sixty percent of men had dentures and, of those with their own teeth, 80% required treatment (56). While free dental care was eventually extended up to the age of 16 years in 1947, by means of an adolescent dental service staffed by private practitioners contracted on a fee-for-service basis, free dental care was not extended to adults under the social security scheme (17). As a result, the establishment of the General Dental Benefit Scheme (as the adolescent service became known) appeared to merely shift the age at which New Zealanders developed oral health problems. Previously, on leaving the SDS at aged 12 or 13 years, and no longer having free dental care, children developed oral health problems during adolescence. Now that free care was available up until the age of 16 years, problems developed between 17 and 20 years of age. Affordability of care was neither mentioned by Saunders nor the NZDA, however, and neither were the other social determinants of health considered, such as employment or having money for housing and food, which were priorities during the Depression and War. Most of the blame for poor oral health was laid on young people or their parent's "don't care" attitude to oral health and to the prevailing New Zealand belief that problem teeth should be extracted and dentures were inevitable (57).

THE SDS AND THE "BABY BOOM"

From the end of World War II up until the 1970s, the SDS struggled to meet its goal of providing care for all school children. In this era, social conditions played a major role in the further development of the SDS. Postwar labor shortages and a "baby boom" put pressure on many health services, as well as preschool, primary, and tertiary education. Rather than achieving full coverage of all primary schools as previously predicted, the SDS found it difficult to keep up with the number of children being born, with staff shortages a major factor.

During the war, women had been encouraged to work; all women between 18 and 40 were required to register for "man-powering" but when the men returned from war, the Government's rehabilitation program promised them a return to full employment (26). This created an exodus of married dental nurses from the SDS who resigned when their husbands came home. Although the numbers of dental nurse students in training had increased, the overall numbers in the field decreased (55), and other professions, such as the teaching and nursing, were also facing shortages (26). As a result, the Government promoted recruitment of married women and allowed them to be permanently employed. While postwar policies encouraged women to return to their homes, the State undermined domesticity by encouraging women to re-enter the workforce (26).

The labor shortages were exacerbated by the "baby boom." The baby boom in New Zealand has been described as having two distinct phases; the first phase in 1945–1946 being a "family size catch-up," following low fertility rates during the Depression and the war, while the second phase, in which large family sizes became the norm, lasted until the early 1970s (58). The SDS developed innovative recruitment campaigns, as did teaching and nursing, to recruit young women to their professions and encourage married women back to work. This was further hampered, however, by the fact that the birth rate during the Depression had been low; therefore, the school-leaving cohort was small (26). To further deal with staff shortages, Saunders had negotiated an "emergency plan" with the NZDA. Upper primary school classes could be transferred to "general dental benefits" and be treated by dentists, thus enabling the dental nurses to concentrate on the younger patients, including the ever-increasing preschool roll (28).

The SDS continued to receive support from successive Governments in the face of its staff shortages. Two new training schools were built in the 1950s, one in Auckland and one in Christchurch (59, 60), and further expansion to the training

occurred in the 1960s when the service established a number of "section clinics," built on primary school grounds (61). The student intake reached a peak in 1964 and 1965 with over 270 students being enrolled each year into the program (**Figure 6**). By the end of the decade, there were 1,334 dental nurses in the field and by March 1970 the number of children under the care of dentists had been reduced from 16,949 to 9,159 (62). It was anticipated that the patient group would soon include, for the first time, every primary school child in the country, and many of the preschoolers (63).

EFFORTS TO IMPROVE ORAL HEALTH

While the SDS's main focus seems to have been "full coverage," efforts were made to further improve its effectiveness, particularly in preventing dental caries. From the early days, as well as providing oral health instruction at the chairside and dental health education in the classroom, dental nurses carried out various forms of preventive treatment, including cleaning teeth, applying silver nitrate to arrest early carious lesions and prophylactic odontotomy, which involved filling the deep fissures of permanent molars in order to prevent decay of those fissures (64). The introduction of fluoride to the SDS, however, was perhaps of most benefit in preventing caries. By 1950, dental nurses were applying fluoride to children's teeth (65) and in 1966, evaluations found that this method of fluoride application significantly reduced caries in children (66).

New Zealand was one of the first countries to instigate water fluoridation, supported by a parliamentary system that held political and fiscal responsibility for decisions on the health and welfare of its people. Fluoride was first introduced, initially on a trial basis, into the water supply in the town of Hastings in 1953. Results of the trial showed that after 16 years' continuous fluoridation, for children aged 13–15 years caries prevalence was reduced by 50%, and for 16-year-olds, by 40% (67). By this time, 60% of New Zealand's population was on a reticulated water supply using fluoridated water and continued water fluoridation meant that dental nurses were able to handle higher roll numbers (68, 69). Where fluoridation had been in operation for some time, the amount of treatment required was reduced. For example, in March 1970, 14,845 more children were under treatment than the previous year but the total fillings required fell by 66,481 (62, 70).

FIGURE 6 | The Dominion School for Dental Nurses, Wellington—showing many students and staff, early 1950s [Archives New Zealand/Te Rua Mahara o te Kawanatanga, Wellington Office (Archives Reference: ABKI 667/3)].

There were, however, few surveys done on the general oral health status of New Zealanders in this era. Oral health surveys of army recruits in the 1950s revealed that there had been a reduction in their loss of teeth (71), while a survey of young adults carried out in 1962–1964 found that the DMFT for 15- to 19-year-olds was 16.73 with 3.2 decayed and 0.88 missing teeth, suggesting a level of unmet need and quite a high level of tooth loss for this age group. Although "race" was collected from those surveyed in 1962–1964, the findings do not differentiate by ethnicity or socioeconomic status so it is not clear whether there were inequalities in oral health during this period (72). When looking at general health, however, there was an awareness at the time that there were inequalities in health between Māori and European but little attempt was made to quantify differences until the late 1950s, most likely due to the fact that Māori health policy before that promoted assimilation (9). In April 1960, the Department of Health published "Māori-European Standards of Health" which "… [indicated] very clearly that the health standards of the Māori [were] very low in comparison with the European" (73). Given that there were inequalities in other health areas, it is likely that this was also the case for oral health.

Later in 1960, J.K. Hunn's "Report on the Department of Māori Affairs 24 August 1960" examined issues such as land, housing, and education, the outcome of which led to a commitment to eliminating differences based on inequality or discrimination. This was perhaps the first occasion where there would be official acknowledgment that social or structural factors (such as education, occupation, and income) play a part in determining health. As a result of this report, the Department of Health acknowledged that "…adverse environmental conditions give rise to consequential disadvantages, in health and otherwise, for many Māoris (*sic*) and there is little that the [Māori Health] committee can do to alleviate these circumstances" (74). The 1950s were, in fact, a period of great change for Māori, as this was a period of Māori migration into the cities to take advantage of the new employment opportunities that became available after World War II. While for some, this led to wider educational and employment opportunities; for others, the cultural and social dislocation led to issues, such as alcohol and drug abuse, violence and crime, and physical and mental health issues. With the Māori workforce being mostly unskilled and in lower-paid employment, they were more vulnerable in times of economic downtown, which in turn had an effect on health. Fewer educational qualifications led to lower-income jobs or unemployment, resulting in lower standards of housing and health, including most likely oral health, given that dental treatment over the age of 16 years had to be paid for by the individual (75).

Efforts made to improve inequalities in health in this era (1950s, 1960s) focused on issues, such as infant mortality, health of Māori mothers and infants, and tuberculosis, with Māori health policy being incorporated into public health and hospital policy. By the end of the 1960s, the official Department assessment of "Māori health trends" was optimistic; however, other commentators had different views. The Editor of the *New Zealand Medical Journal* described the emphasis on Māori health as "…our particular problem with underprivilege in the midst of plenty" (9).

THE SDS: FROM CELEBRATION TO CRITIQUE

The 1970s started on a high note, with the SDS celebrating its Golden Jubilee in 1971. Messages of congratulation were received from all quarters celebrating the progress of the Service (76–79). By this stage, New Zealand was considered by many countries to be a world-leader in providing dental services for children. Progress continued into the mid-1970s, with the SDS finally achieving its goal of "full coverage" for all primary school children, as well as approximately 65% of preschoolers, by 1976 (80). Some 1,341 school dental nurses were working in 1,297 clinics, taking care of 582,964 preschool and school-age children (**Figure 7**) (76). The extraction-to-filling ratio had decreased further and was now only 2.8 extractions per 100 fillings (78). However, as the decade progressed, the dental profession would become aware that there were still challenges ahead in regard to improving the oral health of New Zealanders.

In 1973, the World Health Organization (WHO) conducted the International Study of Dental Manpower Systems (ICS I) in several countries, including New Zealand. This study found that 8- and 9-year-olds and 13- to 14-year-olds in the Canterbury region had a low unmet need for restorative treatment, which indicated that the SDS was successful in meeting their treatment needs, but that they had heavily filled teeth (82, 83). The 13- to 14-year-olds who had enrolled with the SDS at the age of 5 years in 1965 would receive, on average, a total of 37 restorations (in both deciduous and permanent teeth, and including filling replacements) (71). There clearly was a need to concentrate more on the prevention of caries rather than control of caries through fillings.

Some 36% of the 35- to 44-year-old New Zealanders in the WHO study were fully edentulous. New Zealand had the highest percentage of adults from this age group with no natural teeth when compared with the other countries surveyed (82). The Editor of the *New Zealand Dental Journal* claimed that before the survey, "New Zealand dentistry tended to be rather smug" and had boasted to the rest of the world that they had "…the greatest SDS the world had ever seen." "The alarmingly high level of edentulousness in New Zealand shook [them] all out of [their] smugness" (84).

The findings of the WHO survey prompted the New Zealand Dental Research Foundation to carry out its own Survey of Adult Oral Health and Attitudes to Dentistry (SAOH) in 1976. This study had similar findings to the WHO survey. By the age of 20 years, New Zealanders had approximately half of their teeth decayed, missing, or filled. By 40 years, this figure had risen to 75% and by 65 years, to 96%. For those under 20 years of age, there had been a reduction in dental decay in more recent years but periodontal disease was an issue, and oral hygiene was inadequate at all ages. One-third of those over 20 did not have their own natural teeth (85, 86).

Further analysis of the WHO survey revealed that the state of adult oral health was also dependent on socioeconomic status and whether New Zealanders lived in rural or urban areas. Those in lower socioeconomic groups were less likely to visit dentists and more likely to have dentures due mainly to the cost of dental care (82). Peter Davis, a sociologist involved with the SAOH, observed that the SDS did not "…eradicate the 'social class gradient,' nor did it reduce the rural-urban difference" (17). The SAOH had similar findings in regard to socioeconomic status and this survey also differentiated between ethnic groups, finding that Māori were more likely to have poor oral health than their

FIGURE 7 | Dental clinic and dental nurse, 1970s [Archives New Zealand/Te Rua Mahara o te Kawanatanga, Wellington Office (Archives Reference: ABKI W4078 667/3)]. Cuts to health funding from the late 1970s meant that the School Dental Service had difficulties in keeping up-to-date with modern procedures, e.g., the introduction of block anesthesia and radiography, and less money was available for new dental materials and modern equipment. Poor working conditions and a lack of career progression would lead to dissatisfaction within the workforce. What had once been an innovative service was rapidly becoming outdated (81).

European counterparts. This survey was perhaps the first to note that "dentally advantaged and disadvantaged" groups existed in New Zealand society (86).

CHILD ORAL HEALTH INEQUALITIES REVEALED

The findings of the previously mentioned surveys, initially presented in a Symposium at the Dental School, led to a workshop of key stakeholders being held in Rotorua in 1978, from which several recommendations were made (17). Of relevance to the SDS were targets put in place to reduce dental caries within the next 10 years, which included reducing the dmf for 5-year-olds to 3 and the DMF for 12- to 13-year-olds to 5. The goal for the percentage of caries-free 5-year-olds was set at 50% (then 34%), while the goal for 12- to 13-year-olds was 20% (then 2.4%) (87).

The SDS acknowledged that their diagnosis of caries required reassessment and dental nurses were now actively discouraged from restoring early carious lesions, with direct fluoride treatment of early carious lesions being advocated (88–91). A 30-min "preventive appointment" was introduced to the SDS involving early detection of disease, clinical preventive care, and chairside counseling (92). Targets set in place for reducing the numbers of fillings resulted in a 55% reduction between 1977 and 1981 (91). In 1980, a new ratio was introduced to evaluate the increased emphasis on prevention, that of fillings in *permanent* teeth per child. Using this ratio, a retrospective examination of record revealed that in the years 1976–1981, a 64% reduction in fillings had occurred (91).

Surveys carried out by the Health Department on 12- to 13-year-olds in 1977 and 1982 showed that while DMFT had decreased between the years surveyed, non-European children and children from non-fluoridated areas were likely to have poorer oral health, with their DMFT scores, on average, 15% lower than their European and fluoridated area counterparts (93) (**Table 2**). Surveys carried out on 5-year-olds also demonstrated a decrease in dmft over the period; however, dmft was "substantially higher" for non-European children (94) (**Table 2**). These surveys showed that 47% of preschoolers were enrolled with the SDS by the age of 3 years and 87% by the age of 5 years but also revealed that non-European children were less likely to be enrolled in the SDS (94). Oral health data from the Dunedin Multidisciplinary Health and Development (DMHD) study revealed similar patterns. The data for children at age 5 suggested that there was a socioeconomic gradient in dental caries between children living in fluoridated and non-fluoridated areas, with the gradient being more obvious in children in non-fluoridated areas (95).

TABLE 2 | The dental caries experience of New Zealand children in 1977 and 1982 (93, 94).

	European	Non-European	Fluoridated[a]	Non-fluoridated	All children
DMFT of 12- and 13-year-old children					
1977	6.7	8.6	6.3	7.8	7.0
1982	3.6	4.3	3.6	4.2	3.7
dmft of 5-year-old children					
1977	3.3	6.1	3.4	4.2	3.7
1982	2.2	3.9	2.3	3.0	2.6

[a]*Lifetime fluoridation.*

The likely reason that oral health inequalities had gone unnoticed prior to the 1980s was partly due to the Division of Dental Hygiene's method of monitoring oral health, which did not distinguish between ethnicities. The Department of Health was probably not fully aware of this developing child oral health issue. Furthermore, although some attempt had been made to quantify differences between Māori and European general health since the late 1950s (9), oral health does not appear to have been considered. As a result of concerns about "worrying statistics," the Medical Research Council of New Zealand had commissioned Dr. Eru Pomare to undertake a study of Māori Health Standards covering the years 1955–1975. Published in 1980, Pomare's research confirmed that Māori health was worse than that of Pākehā[2] (European) for many conditions, such as coronary heart disease, cancer, diabetes, asthma, rheumatic fever, and mental health issues (96). That this report (or Pomare's second report reviewing the years 1970–1984) does not mention oral health indicates that oral health was not always considered to be a part of general health (96, 97). While there may not have been much information available on the differences between Māori and Pākehā oral health at the time of publication of the first report, results of several surveys would have been accessible by the time the second report was published.

It is also possible that the SDS's prior emphasis on providing "full coverage" of dental care, and the focus on reducing dmft/DMFT from the late 1970s, came at the expense of evaluating thoroughly the care already being provided. This was evident in a paper written in 1984 to explain evaluation in dental public health in New Zealand; while it noted improvements in oral health as a result of the efforts of the SDS in response to the oral health surveys of the 1970s (ICS I and SAOH), it failed to acknowledge that these surveys, and the more recent Health Department surveys for 5-year-olds and 12- to 13-year-olds, had identified inequalities in oral health between groups of New Zealand children (91). By 1986, the SDS had achieved the goals set at the Rotorua workshop and also those of the WHO set in 1981[3] (91, 98, 99). When the WHO carried out the second part of its International Collaborative Study (ICS II) in 1988, New Zealand showed a dramatic improvement in oral health for all age groups but ICS II also revealed socioeconomic and ethnic differences in oral health status, with Māori and those in lower socioeconomic status groups having poorer oral health (100).

It is very likely, however, that socioeconomic and ethnic inequalities in oral health became more apparent in the late 1970s and 1980s because this was a time of great change for New Zealand. Economic conditions and resulting policy decisions would have a major effect on health during this period.

[2]Pomare, being Māori, would use the word Pākehā to describe New Zealanders of European descent. The term varies depending on the publication. The authors have used the terms as stated in the original publications.

[3]The WHO goals were to be achieved by the year 2000. They were similar to the ones set at the Rotorua workshop (to be achieved by 1988) but the WHO had set a DMF of 3 for 12- to 13-year-olds, which New Zealand subsequently adopted.

The previous two decades had been a period of record economic growth which both supported New Zealand's Welfare State and enabled the Government to further extend the SDS. During the 1970s, however, economic growth slowed dramatically and, by the end of the decade, restraints on Government expenditure, including health, had been imposed. New Zealand was no longer able to afford its Welfare State. Under a National Government (1975–1984), led by Prime Minister Robert Muldoon, New Zealand experienced an economic setback described by one commentator as the "…most prolonged postwar recession amongst the industrial capitalist countries" (7). Inflation was high, unemployment rose, and inequalities in income increased. All of these impacted negatively on health, particularly among the Māori and Pacific communities, who were more likely to be unemployed and earning less.

Pomare's second report (1970–1984) showed that while economic conditions affected health status for Māori, cultural and social conditions also had an impact. Pomare observed that: "Māori people [were] grossly disadvantaged socially, economically and culturally" (97). They were more likely to have fewer educational qualifications, be over-represented in prison, living in poor housing, all of which impacted on both physical and mental health. The majority of Māori occupied the lower socioeconomic bracket and this, combined with cultural factors, was considered among the most important reasons that Māori experienced more ill health. Māori were less likely to have money available for medical care, nutritious food, and adequate housing. Where oral health is concerned, the SDS may have been free, but Māori may have been less able to access it or pay for transport to clinics. Culture and self-worth was also considered an essential component of health for Māori and Pomare noted that many Māori might not access available services due to cultural barriers (97). This could also explain why Māori would not necessarily attend a free SDS, staffed by predominantly Pākehā female dental nurses, and run within an essentially mono-cultural health system.

Despite the increase in inequalities in health during the 1980s, this period would mark a turning point in terms of health policy for Māori. In 1984, Māori health advancement was identified as a priority at two Māori Health Hui (meetings), with Māori also expressing a desire to provide health services to their own people.[4] While Hunn's 1960 report had been credited with moving Government policy from assimilation to integration for Māori, the 1980s would see a commitment to biculturalism in policy (101). For the Department of Health, this meant taking steps to include Māori perspectives in its policies and practices, as well as formally acknowledging the relevance of the Treaty of Waitangi to health provision (9). Furthermore, legislation would ensure that the Crown, the Government, and the health sector could easily consult with Māori (101).

THE END OF AN ERA

The early 1980s had seen a downsizing of the SDS; as well as requiring the SDS to reduce salary costs (102), the Minister of Health instigated a review of dental nurse training that resulted in the closure of the Auckland and Christchurch training schools. While the review could be partly attributed to the need to save money, there were other factors to consider as well. The birth rate was now in decline and the average number of fillings per child had fallen from 5.0 in 1965 to 1.8 in 1979. In addition to this, there were 400+ dental nurses on either special leave or former dental nurses wanting to return to work (103). However, more significant change was ahead for the SDS.

While in power, the National Government (1975–1984) had proposed that 14 regionally-located, locally-elected Area Health Boards (AHBs) be established with the intention being to amalgamate the existing Hospital Health Boards and "…integrate their (curative) functions with the Department of Health's (preventive) district health offices" (104). The subsequent Labour Government (1984) chose to continue with this concept and introduced a population-based funding formula to make the most efficient use of an already-reduced health budget, and to shift the previous focus from hospitals to include epidemiological factors and public health programs (104). The Department of Health was subsequently restructured; with most administrative and service delivery functions transferred to the AHBs, it now had a policy development and implementation role (105).

The move to AHBs has been described as the "end of an era" for the nationally directed SDS (105). Responsibility for the management of the Service was now delegated to the 14 Boards, in effect replacing a centralized Service with 14 independent regional SDSs (105). In a time of financial restraint, it may have been tempting for AHBs to divert money away from the SDS to other Board services; however, on being appointed Minister of Health in 1989, Helen Clark opted to retain responsibility for primary care and general practice services within the Department of Health (104). The Department would remain accountable for SDS policy and funding. Furthermore, the Minister viewed the SDS as having a "…central role in oral health promotion and disease-prevention methods," and dental nurses able to extend the areas within which they could work, based on population needs (106). Moreover, acceptance as the SDS as a public institution was embodied in the widespread (and somewhat pejorative) use of the term "murder house" (107).[5]

THE EARLY 1990s ATTACK ON THE WELFARE STATE

With the passing of time, it became apparent that the capacity of the SDS and other dental clinical services to prevent oral diseases was rather limited and that the major determinants of poor oral health lay beyond the reach of those services. This was most notable in a steadily worsening lack of control over the cariogenic environment, together with deliberate, neoliberal-inspired social and economic policy decisions that were taken in New Zealand in the early 1990s. These included cuts to welfare benefits in 1990,

[4] Hui Whakaoranga and Hui Tamata.

[5] Generations of New Zealand children referred to the school dental clinic as the "murder house," due no doubt to the extent of treatment many required and the fact that, up until the late 1970s, local anesthetic was rarely used for filling work.

the introduction of "market rents" for State housing in 1991, and the introduction of the Employment Contracts Act, also in 1991, which, in favoring individual negotiation over collective bargaining, essentially depowered the trade union movement. Neoliberal policies such as these lead to social inequality, which in turn leads to inequalities in health (108). Higher income inequality is also likely to affect social cohesion, another important determinant of health (109). In New Zealand, the Gini (income inequality) coefficient increased from one of the lowest in the OECD to one of the highest by the mid-1990s. Māori were much more affected by these structural reforms, being more likely to work in the laboring, manufacturing, and less-skilled service industries, sectors that bore the brunt of the reforms. Unemployment rose from 11% in 1986 to 25% in 1992 for Māori, while European unemployment peaked at 8%. Poverty among Māori households rose from 14 to 41% compared to an increase of 8 to 17% for Europeans (108). Overall, these ill-advised social policy initiatives resulted in many more New Zealanders living in poverty and caused a rapid widening of ethnic inequalities in child oral health over the subsequent 5 years (**Figure 8**) (110).

During this time, New Zealand also underwent a series of health "reforms," aimed to reduce the role of the State in health care, and increase efficiency, choice, and responsiveness for consumers. These changes had a negative impact on school dental services, however, including redundancies for dental nurses (now called dental therapists). Increased workloads for dental therapists, along with mobility between clinics, led to a focus on treating caries with little time for preventive care and health promotion. SDS data for the 1990s show that while the mean mft scores for 5-year-olds fell between 1990 and 1996, they began to rise after that. Similarly, the mean MFT scores for year 8 (12- to 13-year-old) children declined from 1990 to 1994, then increased until 1997 before leveling off over the next 2 years (**Figure 9**) (111). One positive outcome of the 1990s health reforms, however, was an increase in Māori Health Providers who were able to secure contracts to provide services for Māori, and those included oral health services. These providers are owned by Māori, are operated under kaupapa Māori (Māori ideology and practice), and offer a whānau ora (family health) approach to care (101, 104, 112).

GOOD ORAL HEALTH FOR ALL, FOR LIFE

Having suffered through a series of market-oriented "reforms" that emphasized efficiency over equity as a system goal (113), New Zealand had a change of Government in 1999. The new Labour Government introduced further changes, this time to improve disadvantaged social groups' access to health care services. However, the neoliberal economic models that had gained global ascendancy during the 1980s and 1990s created obstacles to many of these policy actions. The New Zealand Government, like others of the time, embraced the principle of intersectoral action to address the broader social determinants of health. Under the banner of "Health for All," the overarching goal was to improve the health of disadvantaged groups and reduce inequalities in health, and the Government would

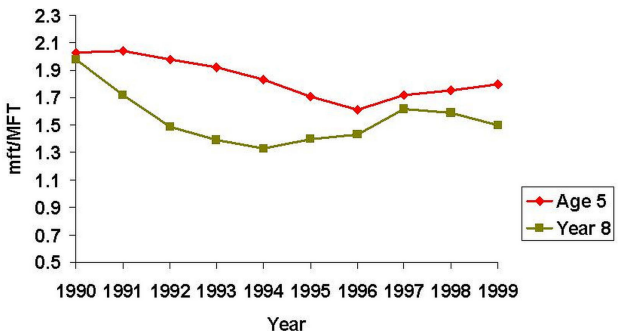

FIGURE 9 | Trends in dental caries severity among 5-year-old and year 8 (12- to 13-year-old) children during the 1990s (111).

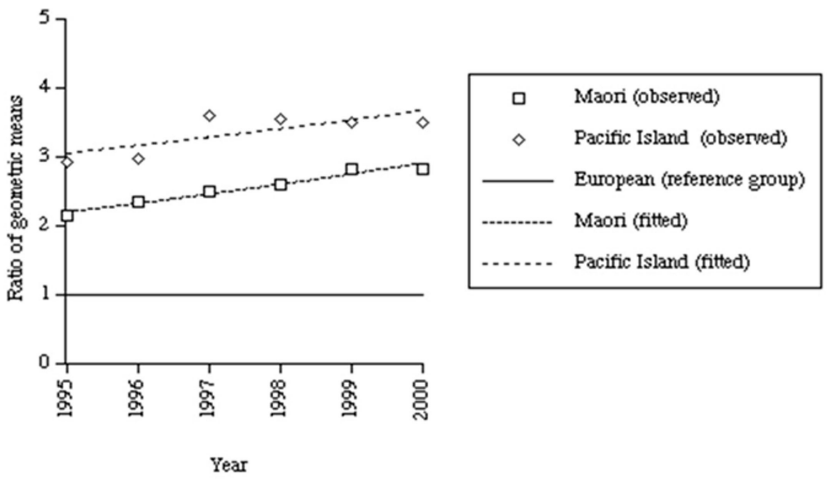

FIGURE 8 | Evidence of widening in ethnic inequalities in deciduous dentition caries experience among Wellington 5-year-olds after the early-1990s social and economic policy "reforms" [from Thomson et al., (110); reproduced with the kind permission of the *Australian and New Zealand Journal of Public Health*].

make this a priority within the health sector and wider policy arena over the next decade (114). However, some policies were controversial, for example, the "Closing the Gaps" affirmative action strategy pitched at Māori was widely criticized as showing favoritism to Māori at the expense of other equally disadvantaged groups.

The New Zealand Health Strategy (2000) specified "improving oral health" as one of 13 health priorities and one of 12 priorities for Māori health, thus demonstrating the Government's acknowledgment that poor oral health was still a major issue for New Zealanders (114). A report to the Minister of Health in 2002 further confirmed that although child oral health had improved over the years, oral health inequalities were significant for Māori and Pacific children and adolescents, and children and adolescents from low socioeconomic backgrounds (111). Moreover, research on the oral health of participants in the DMHD Study found that although free dental care during school years reduced the effect of SES inequity, "profound" socioeconomic differences re-emerged by the age of 26 years, and high disease experience early in life led to greater disease experience in adulthood. Recommendations for tackling these oral health inequalities included targeting the social determinants of health and developing more suitable oral health services (115). Unfortunately, the previous years of reduced funding had left a SDS with poor working conditions and a dissatisfied staff with poor morale, this being further confirmed by national SDS facilities and workforce reviews (116–118). These reviews, along with the "Improving Child Oral Health and Reducing Child Oral Health Inequalities" strategy (111), would become the basis for a new strategic vision for oral health, "Good Oral Health for All for Life" (GOHFAFL). This was an opportunity for the Government to re-orientate the delivery of publicly funded oral health care in New Zealand (119). It represented a change in the assumptions that underlie the delivery of oral health care and required oral health to be placed in the context of other health strategies.

Good Oral Health for All for Life comprised seven "action areas," these being the reorientation of the child and adolescent oral health service, reduction in inequalities in oral health and access to oral health services, promotion of oral health, building links with primary health care, building an appropriate oral health care workforce, development of oral health policy, and ongoing research, monitoring, and evaluation. Each District Health Board (DHB) was to develop a plan (business case) to suit the needs of its community, with a focus on prevention, early access for care, and a seamless service that provided care for children from birth to age 18 (**Table 3**). Significant Government investment funded new community-based clinics and mobile dental vans, complete with new equipment and modern technology. Dental therapists no longer worked in isolation; they now worked as part of a team, aided by dental assistants and administrative staff (119).

New Zealand's 2009 Oral Health Survey showed that large improvements in oral health have occurred for children since the 1980s; the proportion of 12- to 13-year-olds who were caries-free almost doubled between the time of the last oral health survey in 2008 (28.5%) and 2009 (51.6%). DMFT has also significantly decreased for this age group (from 2.4 to 1.3). However, the 2009 survey also found that significant disparities in oral health status and access to care still existed for Māori and Pacific children and adolescents (1). In recent years, COHS 5-year-old and year 8 average dmft/DMFT and caries-free data also suggest that, overall, oral health for New Zealand children is improving but that inequalities in oral health persist (**Figure 10**) (120, 121). For Pacific Island 5-year-olds, there is an apparent worsening of oral health but it is not yet known whether this is a longer-term trend (**Figure 10**) (120). There is anecdotal evidence to suggest that, in some regions, inequalities in oral health are narrowing, however, particularly in areas where the COHS has a strong preventive approach.

However, caries prevention challenges persist. The ongoing consolidation of neoliberalism as the organizing principle of modern society has led to what has been coined the "neoliberal diet" (122): this is the energy-dense and nutritionally compromised industrial diet—highly processed and convenient "junk" food—which was the outcome of the U.S. agricultural subsidy policies of recent decades. Such food is high in sugar, salt, and fat. It has low nutritional value but is cheap, available, and requires minimal preparation. It tends to be consumed by those on low and/or insecure incomes, whose numbers are steadily rising as a consequence of neoliberal policies. Sugar intake is the most important dietary risk factor for dental caries (123), yet the marketing of sugar-laden food and drink continues unabated, with the true sugar content unapparent to most consumers. Attempts to restrict such marketing are strenuously resisted by food industry lobbying, despite the fact that some of the most popular supermarket products sold in New Zealand are less healthy (full-fat milk, white bread, sugary soft drinks, butter, and sweet biscuits) (124). Early childhood caries (ECC) shows no signs of disappearing and recent

TABLE 3 | A comparison of oral health approaches [adapted from Ref. (119)].

School Dental Service	Community Oral Health Service
An emphasis on treatment	An emphasis on prevention and early intervention
A division between oral health and general health	Oral health is integrated into general health frameworks
District health boards (DHBs) provide services	There is a mix of service providers, including DHBs, primary health organizations, Māori and Pacific providers, and non-governmental organizations
School-based dental services for children	Community-based dental services for children, with the potential to expand to adolescents and low-income adults
Separate funding for child and adolescent oral health services	Funding that allows flexibility of service program design
An emphasis on primary school years	An emphasis on preschool and early primary school years
Clinicians work in isolation	A team-based approach to oral health—dentists, dental therapists, and dental assistants work together
A small Māori and Pacific oral health workforce	A workforce more representative of the ethnic diversity of New Zealand
Pressure on secondary services	Greater capability at the primary care level, with secondary services focused on patients who cannot be managed by primary care

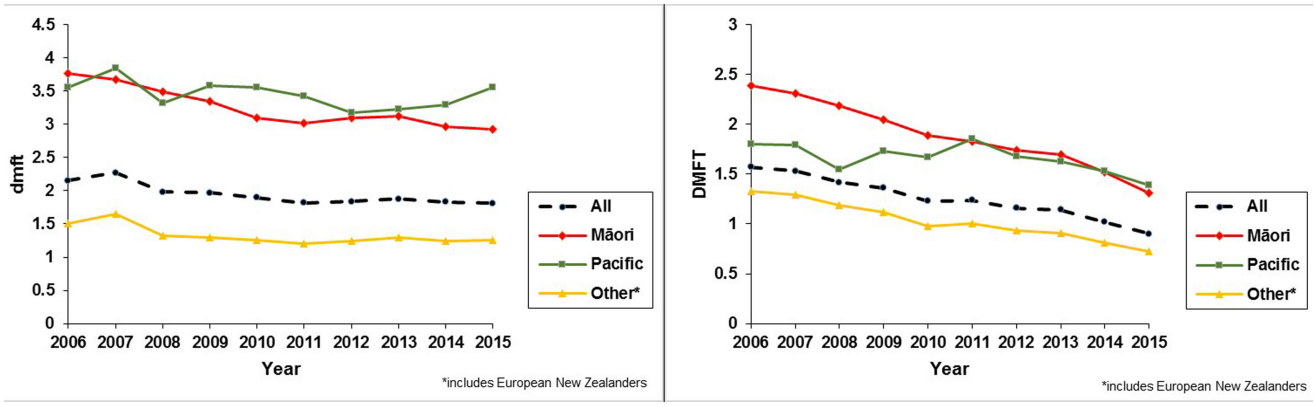

FIGURE 10 | Dental caries experience of 5-year-old and year 8 (12- to 13-year-old) New Zealand children from 2006 to 2015. The data in these line graphs represent cumulative dental caries experience among 5-year-olds (dmft) and 12- to 13-year-olds (DMFT) for all of New Zealand over a 10-year period (120).

research shows that ECC is actually increasing. The numbers of children being treated under general anesthetic nationally have increased by 60% since 2004 and there are increases in ECC prevalence, for example, from 16.6% in 2009 to 23.3% in 2013 in Canterbury (125).

Addressing oral health inequalities, particularly in relation to Māori and Pacific Island children, was a priority for the new model of care. DHBs were encouraged to contract Māori and Pacific Health Providers to provide oral health services suited to the needs of their communities, for example, in the case of Māori, providing a whānau ora approach to care (119). This new vision/policy attempted to garner the participation of these communities in the design and implementation of the re-orientated COHS, identifying this as essential in addressing the social determinants of health. Although encouraged within GOHFAFL, in reality, financial constraints, historical and cultural institutionalism, and traditional oral health care delivery models reduced the full impact of this new policy in the most-affected communities. This has most likely resulted in a new service that is not innovative enough to overcome the structural determinants that exist in New Zealand society and which still excludes those who are most disadvantaged.

While the changes in service delivery and the effect on inequalities in oral health outcomes are yet to be fully examined, the Institute of Environmental Science and Research Limited (ESR) was contracted by the Ministry of Health in 2014 to evaluate and report on the reorientation of services. The Ministry of Health had set up a "Quality Improvement Group" for Māori Oral Health Providers and this group was interviewed as part of the evaluation (112). They felt that they had had variable input into the business plans, depending on which DHB they belonged to. They indicated that, while they had been consulted, the DHBs addressed their own needs, focusing on the aging workforce, equipment, and facilities, believing that this would address inequalities in oral health for Māori children. The new COHS, was "…just a retrofit of the old school dental system and a huge missed opportunity to do something really different," such as implementing a whānau ora model where the whole whānau could be seen and treated together. Māori Oral Health Providers also had concerns about widening inequalities between Māori children and others, because Māori were more likely to live in rural areas and be socially disadvantaged and unable to travel to hub clinics (126). Dental therapists interviewed for this report, and another study conducted in the Southern region of New Zealand, also believed that those with the most need were less likely to be able to access clinical services due to unavailability of transport or parents being unable to take time off work to bring their children (126, 127).

THE DENTAL THERAPY WORKFORCE

There is evidence, however, to suggest that inequalities in oral health narrow during childhood and adolescence in New Zealand with access to free dental care and that these widen again after the age of 18 years (111, 115). Recent research, comparing adult oral health in several countries, has confirmed that indigenous people, including Māori, have a higher prevalence of decayed and missing teeth than their non-indigenous counterparts (128), and there are distinct social gradients in tooth loss (129). While the fact that oral health declines once New Zealanders must pay for their own dental care has been recognized for many years, previous Government policy has failed to address this issue. Both the New Zealand Health Strategy and GOHFAFL acknowledge that future policy work needs to focus on what care can be provided to low-income adults, with GOHFAFL suggesting that community-based facilities may develop the capability to provide services to lower-income adults (114, 119). While the 1988 Dental Act restricted dental therapists to working in public practice, there was no age limit on the patient group they could care for; dental therapists in some DHB areas treated low-income adults. Subsequent legislation (Health Practitioners Competence Assurance Act 2003) resulted in dental therapists being limited to caring for patients up to 18 years of age, with only a small number being eligible to register in an additional adult scope of practice. While New Zealand's "oral health" graduates currently register as both

dental hygienists and dental therapists, and can work in private and public practice, their restorative skills remain confined to patients aged under 18 years (130, 131). An opportunity existed to include these skills in the new "oral health therapy" scope of practice (to be implemented in November 2017); however, opposition at the consultation stage resulted in this being removed (132, 133).

The dental therapy workforce has been aging for some time, with the average age of the New Zealand dental therapist being over 50 years (117, 134). DHBs will need to further develop ways to recruit, and retain, dental and oral health therapists, particularly since New Zealand oral health therapists are also able to work in private practice and can practice both dental therapy and dental hygiene. Enabling graduates to use both sets of skills in a DHB setting will offer graduates a more attractive career path, and be of benefit to the patient group, particularly in caring for patients with special needs. GOHFAFL also advocates for a workforce representative of the ethnic diversity of the New Zealand population, as part of the effort to reduce inequalities. Numbers of Māori and Pacific students enrolled in the health professional degrees are increasing and they are being supported to study by innovative schemes such as the University of Otago's Māori Health Workforce Development Unit's "Te Whakapuāwai: Health Sciences First Year achievement programme" (135).

Dental therapists have been used to improve access to care for low-income adults and indigenous people elsewhere, for example, Alaska's dental health aide therapists (dental therapists), the first of whom trained in New Zealand. In Australia, oral health therapists and dental therapists can treat up to the age of 25 years in their dental therapy scope. The 2009 New Zealand Oral Health Survey found that those of lower income, those aged 18–24 years, and Māori and Pacific Islanders were the least likely to attend for dental care with cost of care being a major factor (1). While there is no specific evidence that enabling oral health therapists to treat lower-income groups in the New Zealand context will improve access to care and make dental treatment more affordable or reduce inequalities, an opportunity to investigate this potential has been lost.

CONCLUSION

The New Zealand SDS/COHS has proved itself very adaptable over the decades in its efforts to improve children's oral health. Nevertheless, inequalities in oral health still exist for New Zealand children and adolescents, and these gaps widen in the adult years. The CSDH framework describes the health system as an intermediary determinant of health; it can directly affect health outcomes in its provision of access to care, and whether or not it promotes intersectoral action and social participation in decision-making, both of which are key to improving health and reducing inequalities. As such, the SDS (now the COHS) can also be considered a determinant of health, with SDS/COHS policy influencing both oral health status and oral health inequalities and, in turn, being shaped by a variety of social, political, and economic forces.

The CSDH framework notes that interventions to improve inequalities in health are often aimed at intermediary determinants of health. This has also been the case in terms of efforts by successive New Zealand Governments to reduce oral health inequalities. At the SDS/COHS level, policy has been directed at early intervention, increasing enrollment and access to care, as well as at increasing preventive care. These have had a positive effect on the oral health of children and adolescents in recent years; however, interventions aimed at the intermediary level often improve health indicators but leave health inequities unchanged. Efforts to reduce inequalities need to be directed at tackling the structural determinants of health, with policies paying attention to contextual specificities and using methodologies developed by social and political science.

Strategies to reduce inequalities must reach beyond the health sector in order to tackle the structural determinants of health. While some issues that affect health inequalities, such as poverty and poor living conditions, need intervention at a Government policy level, oral health services can drive policy change in other areas. In New Zealand, COHS and DHB leadership can create momentum for policy change by lobbying for a tax on sugar, dental treatment for low-income adults, and proposed legislative change to move the decision for fluoridating water supplies from local Government to DHBs.

The CSDH framework promotes social participation as being crucial to reducing inequity and empowering affected communities, and social participation is considered an ethical obligation in policy development. Disadvantaged communities need to not only be consulted and involved in policy decisions concerning their health but also be empowered to take control over these decisions. New Zealand's Treaty of Waitangi requires that policymakers work together with Māori to develop strategies to reduce inequities in health that are relevant to Māori cultural concepts, values and practices. While some attempt has been made to involve Māori and Pacific Health Providers in policies affecting oral health, more effort is required to further reduce inequalities in oral health.

Ongoing monitoring of oral health and evaluation of oral health programs are essential in deciding what initiatives are likely to be most successful in reducing inequalities in the future. In the past, the failure to do so adequately has meant that SDS management was not always aware of oral health inequalities. In 2006, New Zealand's strategic vision for oral health (GOHFAFL) identified "research, monitoring and evaluation" as one of several action areas but, more than a decade on, there is still much work to be done in this area. Finally, reviewing the history of a public service is a form of retrospective evaluation; it can help to avoid repeating mistakes of the past and aid in determining future policy. Furthermore, other countries can learn from New Zealand's experience in their efforts to provide effective and accessible services to improve oral health and reduce oral health inequalities.

AUTHOR CONTRIBUTIONS

All authors, SM, LFP, and WT, have made both direct and intellectual contribution to the manuscript and all have approved it for publication.

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Pioneering and Interprofessional Pediatric Dentistry Programs Aimed at Reducing Oral Health Disparities

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Early Childhood Caries (ECC) is the most chronic childhood disease and more predominant in low-income and underserved children. Although easily transmitted, ECC is entirely preventable. Dr. Ramos-Gomez and his team at the University of California, Los Angeles put together an interprofessional curriculum where both medical and dental knowledge and practice is integrated to prepare dentists and primary care providers to more cost effectively address ECC and thereby reduce disparities in oral health. The curriculum, known as the Strategic Partnership for Interprofessional Collaborative Education in Pediatric Dentistry (SPICE-PD), consists of nine evidence-based training modules: applied statistics and research, community partners, interprofessional education/training, quality improvement, policy and advocacy, disease management/risk assessment, ethics/professionalism, cultural competency and children with special heath-care needs. SPICE aims to prepare pediatric dental residents and primary care providers to provide preventive, culturally competent, and minimally invasive oral care for underserved, low income, and special needs children. Additionally, the Infant Oral Care Program (IOCP), located at a local community health clinic, provides culturally sensitive preventive oral health care for children aged 0–5 years. The medical–dental integration model utilized at IOCP helps reduce oral health disparities by providing a systems-based and cost-effective approach to combat the burden of ECC. To track the progress of SPICE, a comprehensive evaluation framework has been designed, which aligns goals and objectives with program activities, desired outcomes, and measured indicators.

Keywords: children's oral health, early childhood caries, preventive oral health care, oral health disparities, cultural factors, minimally invasive dentistry

INTRODUCTION

As stated in the Surgeon General's 2000 report, Early Childhood Caries (ECC) is the most common chronic childhood disease, with a prevalence five times that of asthma (1). While it is highly infectious and transmitted easily from caregiver to child and from sibling to sibling, it is an entirely preventable disease (2–5). The key to prevention is early intervention and regular preventive dental care based on risk and disease management, but many families only seek dental care when problems occur. Remarkably, 80% of dental disease, including ECC, is concentrated in only 20–25% of the

country's children, who are primarily from low socioeconomic and/or minority backgrounds (5–7).

Early oral health interventions are critical for reducing the oral health disparities long suffered by the children of vulnerable and underserved communities (8, 9). Such interventions must be targeted in a socially, environmentally, and culturally appropriate manner, with a focus on early prevention, behavioral intervention, and collaborative involvement of dental and primary health-care providers.

Medical/dental integration is the goal of the Strategic Partnership for Interprofessional Collaborative Education in Pediatric Dentistry (SPICE-PD) residency curriculum at the University of California, Los Angeles (UCLA) School of Dentistry (10). This program is a continuation of the Community Health and Advocacy Training in Pediatric Dentistry, which spanned from 2010 to 2015. Both programs are funded by a grant from the Health Resources and Services Administration (HRSA), aim to augment and advance the training provided through the UCLA Pediatric Dentistry residency program to prepare dentists and primary care providers to meet the complex and comprehensive oral health needs of pediatric patients from underserved and high-need vulnerable populations more effectively.

The Infant Oral Care Program (IOCP), launched in 2010, is based on the assumption that low-income and minority caregivers visit venues like community clinics and Head Start/Early Head Start and Women, Infants, and Children (WIC) sites earlier and with more regularity than dental clinics. Therefore, these community program sites offer an ideal place where preventive dental services can most effectively be instituted. A low-cost medical–dental integrated preventive dental services model is instituted in these locations to help bridge the gap to better oral health for these underserved populations.

The objective of this paper is to showcase how the SPICE-PD curriculum and the IOCP through targeted and culturally appropriate means contribute to ameliorating oral health disparities and reducing the burden of oral disease.

RATIONALE

Dental education has traditionally focused on surgical treatment of dental care, training oral health providers to rely primarily on restorative methods to maintain their patients' oral health (11). As a result, many dental professionals are undertrained in aspects of preventive care, particularly when it comes to young children. In a 2015 study of 66 US and Canadian Dental Schools and in a study by the London Education and Training programme, it states that there is a lack of adequate science-based preventive dental education and preventive measures patient follow-up. For example, the former study concluded that it is evident that a great deficit is in reevaluation or outcomes assessment for preventive measure (12, 13).

Pediatricians and nurses also lack the training necessary to provide preventive oral health care that is effective. Both the American Academy of Pediatrics and US Preventative Services Task Force state that primary care providers should be knowledgeable on the management and prevention of dental caries (14, 15). Pediatric primary care providers are well positioned to help ameliorate the ECC disease burden with appropriate risk assessment, fluoride varnish application, and referral. Pediatric providers routinely see children for up to 10 well child checks by the time the child turns 2 years old, providing ample opportunity for risk assessment, fluoride application, and referral (16). Unfortunately, many pediatric clinicians lack the training necessary to provide this care. Indeed, a survey of medical schools found that 69% of schools had less than 5 h of oral health in their curriculum (17). Additionally, a survey of graduating pediatric residents found that over a third of pediatric residents who responded did not have any oral health training during their residency. Of those residents who did receive training, only 14% had any clinical time with a dentist (18). Curricula directly addressing this knowledge and training gap in pediatric oral health are needed to help reduce the burden of caries in children. This lack in adequate preventive oral health training results in two undesired and unnecessary outcomes.

First, children suffer needlessly through the pain of oral health disease. Clearly, this affects quality of life for the affected children, but can also impact school performance and overall health (19, 20). Families are also affected, missing valuable hours of work in order to deal with their children's oral health issues. Second, reliance on restorative intervention to maintain oral health also costs our nation. A recent study by Bruen and colleagues on Medicaid expenditures for dental care suggests that, in 2011, there were approximately $450 million in additional Medicaid expenditures in Operating Room or Ambulatory Surgery Center-based surgical care for potentially preventable pediatric dental conditions, primarily related to ECC (21).

The goal of SPICE-PD is to create a framework for interprofessional training between pediatricians, nurses, and dentists that will directly target a known deficit in oral health training, and improve knowledge, confidence, and clinical performance in the prevention of ECC. The next generation of dentists and primary care providers needs to be ready to address the needs of those children most affected by the epidemic of ECC. To do this, it is imperative that we provide adequate community-based learning, incorporating community public health principles, and culturally appropriate preventive oral health-care practices into our pediatric curriculums.

SPICE also aims to enroll underrepresented minorities into their residency program in the hopes that once graduated they will serve and thereby help increase access to oral health care for vulnerable, underserved, or rural communities. Nationally, only about 8% of dental students and pediatric dental residents are Hispanic (22, 23), but 18% of CHAT/SPICE residents are Hispanic and 33% are from a disadvantaged background (2010–2017), far outpacing the national averages for those descriptors for dental students and pediatric dental residents (24).

SPICE-PD: A NEW EDUCATION STRATEGY

The primary goal of the SPICE-PD program is to prepare pediatric dental residents to provide care for underserved and special needs groups and communities in the evolving field of dentistry.

This HRSA funded program (2015–2020) includes nine training modules:

1. Applied statistics and research methods
2. Community partners
3. Interprofessional education (IPE)/training
4. Quality improvement
5. Policy and advocacy
6. Disease management/risk assessment
7. Ethics/professionalism
8. Cultural competency
9. NEW: children with special health-care needs [e.g., craniofacial abnormalities and autism spectrum disorders (ASD)].

Each module is designed to align with the Commission on Dental Accreditation (CODA) Accreditation Standards for advanced education in pediatric dentistry (**Figure 1**) (25). Each mandatory module on the average includes 21 h of didactics and/or hands-on/workshop training. The nine modules supplement the existing pediatric dental residency clinical curriculum.

Some topics, such as Applied Statistics and Research Methods, have long been part of the UCLA curriculum, but have been updated to reflect a public health emphasis, incorporating dental public health principles in addition to more traditional aspects of basic research methods and descriptive/inferential statistics. As a result, nearly 40% of the research topics chosen incorporate a public or community health emphasis, with more than 70% of the Class of 2016 choosing public health projects. Similarly, the Quality Improvement module represents a more traditional aspect of the curriculum, including the use of qualitative and quantitative methods to improve practice efficiency and safety, but also covers ways to improve the effectiveness of service delivery processes, particularly, those geared toward children from underserved and/or vulnerable populations.

Other topics aim to educate dentists on issues important to underserved, high risk, and vulnerable populations. One new module specifically addresses children with special health-care needs. The SPICE-PD curriculum focuses on medically complex special needs patients, as well as a clinical rotation at the Early Childhood Partial Hospitalization Program (ECPHP) at the Resnick Neuropsychiatric Hospital at UCLA, a program for children 2–6 years of age, diagnosed with ASDs and related comorbidities. The prevalence of ASD is disproportionately high in the greater Los Angeles area (26), with the highest distribution in Northern LA County, where the population is comprised primarily of low income families. Children with ASD are much more likely to have poor oral hygiene, decayed or missing teeth, and more likely to need restorative dental treatment

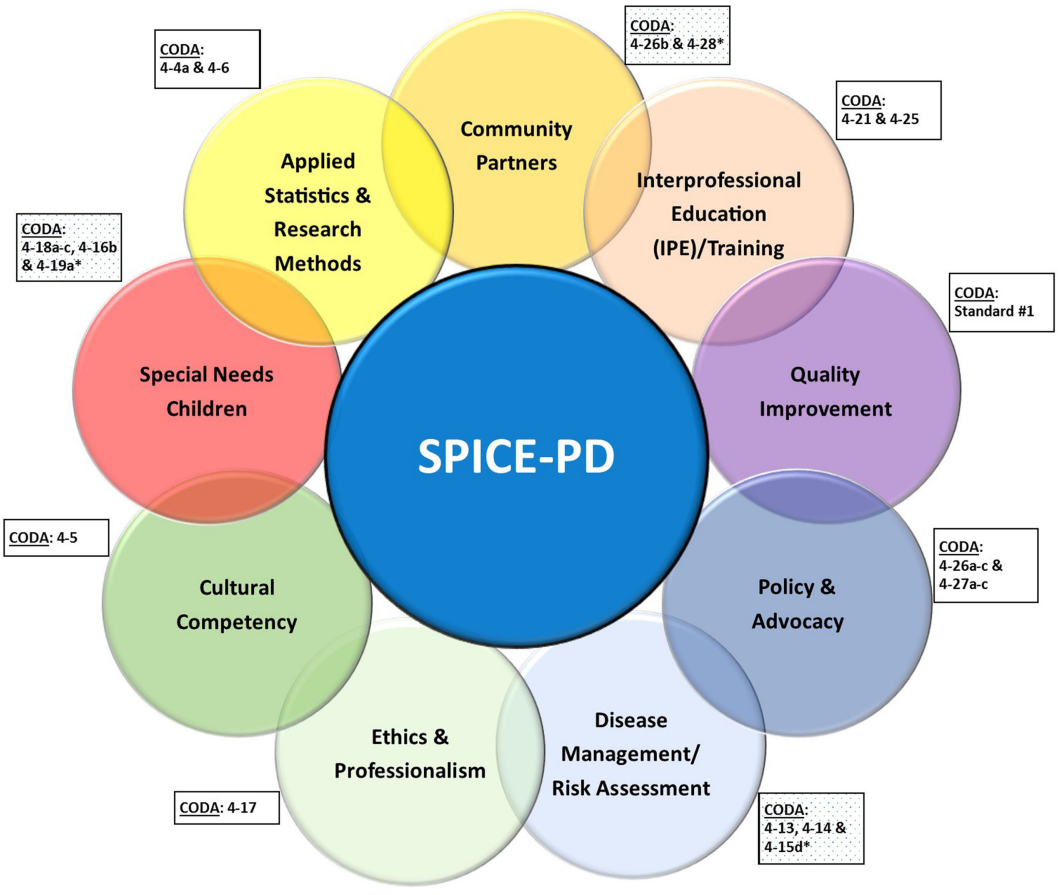

FIGURE 1 | Strategic Partnership for Interprofessional Collaborative Education in Pediatric Dentistry (SPICE-PD) learning modules and their alignment with the Commission on Dental Accreditation (CODA) Standards for advanced education in pediatric dentistry.

(27). SPICE-PD residents train with ECPHP expert faculty to learn the most appropriate strategies for interacting with and providing care to this special population of patients.

Just as residents must become competent in strategies for interacting with children with ASD, Cultural Competency is vital when providing care in a multicultural community. In the Cultural Competency module, residents learn the importance of providing culturally and linguistically appropriate oral health care, while considering the impact of culture on attitudes, behavior, and oral health. This course helps residents identify and address health-care disparities and barriers to accessing oral health care, while developing a greater understanding of how to interact with a wide range of diverse patients and their families.

When addressing oral health in high risk groups, early intervention and strategic disease management are key. The Disease Management and Risk Assessment module stresses the importance of early assessment, diagnosis, and intervention as a means of oral disease prevention management. Early intervention and education are the most effective ways to prevent problems that traditional infectious-disease models fail to address, such as the epidemic of ECC (20, 28, 29). The module provides residents with a background in minimally invasive pediatric dentistry, individual oral health assessment, and treatment for pregnant women, infants, children, and caregivers. Central to this is the use of the Caries Management by Risk Assessment tool (CAMBRA) (4, 7, 30, 31), which provides a method of assessing caries risk in young children, thereby informing treatment plans, self-management goals, and recall schedules. In evidence-based minimally invasive dentistry, which includes use of CAMBRA, fluoride, sealants, and remineralization substances such as Casein Phosphapeptides, the patient/caregiver is encouraged to assume responsibility for the level of infection and is educated, instructed, and monitored in the proper control techniques. It is the patient/caregiver who has the disease, but it is the health professional's responsibility to provide the patient the appropriate tools to overcome it.

Other modules are more directly aimed at achieving public health goals. CODA's standards on Policy and Advocacy state that didactic instruction must cover the fundamentals of child advocacy, including issues pertaining to disparities in oral health-care delivery, such as access to care, as well as discussion of possible solutions (32). These topics are covered in depth throughout many of the SPICE-PD courses. But the new CODA guidelines go even further, highlighting the importance of exposing residents to various aspects of public health advocacy. The Policy and Advocacy module aims to prepare residents to be leaders in their field, advocating for children's oral health and advising public health policy legislation at regional and national levels. Each year, our program sends all program year one pediatric dental residents to actively participate in the annual American Academy of Pediatric Dentistry advocacy days in Washington, DC (33), where they attend meetings with legislators to promote improved access to high-quality oral health care, particularly among vulnerable populations.

One of the most important aspects of advocating at a local level is through collaboration with local groups and community health programs. Community Partners module uses a systems-based approach to provide residents with a foundation for improving pediatric oral health within the context of their own community, laying a critical foundation for understanding the oral health-care delivery system. Specific topics include building relationships with local community organizations, public and private sector payers, and local policymakers. The course covers topics such as the social determinants of health and the problem with access to care, as well as an overview of Federal and State funded health programs, including Medicaid and CHIP, which provide dental care to underserved and financially disadvantaged populations. Pediatric residents must also complete an advanced practicum that involves teaching in community-based programs and teaching other health professionals.

The module on IPE provides pediatric dental residents with instruction needed to cross-train non-dental providers, such as pediatricians and nurses, on oral health disparities and dental development, as well as risk assessment, anticipatory guidance, and application of fluoride varnish. Residents have the opportunity to teach a class on children's oral health to nursing students participating in the IPE program. The IPE course is an integral part of training the residents to work in interprofessional and multidisciplinary teams, which is key for early intervention. In addition to pediatric dental teaching experiences, all residents also cross train in a pediatric medicine rotation. These skill sets may also be utilized in the IOCP, where program year one pediatric dental residents work alongside pediatric medical residents as structured treatment teams. The experiences allows for bidirectional interprofessional exchange of knowledge and experience in caring for the pediatric patient from both the dental and medical perspectives.

The SPICE curriculum also includes training in preventive children's oral health care for UCLA's general dentistry residents. Far more, children in the US are seen by general dentists than are seen by pediatric dentists; therefore, the SPICE curriculum includes a 6-week interdisciplinary children's oral health course for all general dentistry residents.

To track the success of the program, the SPICE-PD evaluation team has designed a comprehensive 5-year evaluation plan. At the center of this plan is the Evaluation Logic Model, which aligns SPICE-PD goals and objectives with program activities, desired outcomes, and measurable indicators. **Table 1** describes the three focus areas (1. Program Development, 2. Learning, and 3. Professional Choices) and the corresponding evaluation key questions and data sources of the evaluation logic model. Each measure is defined with quantified metrics that will be tracked over time to enable measurement of the impact of the educational programs. As an important part of this evaluation logic model, the SPICE-PD team is working to bridge and integrate various electronic medical and dental records for patient tracking and quality improvement.

THE IOCP: INTEGRATED ORAL AND PRIMARY HEALTH

The IOCP (9, 34) was founded in 2010 to address the dire needs of children in Los Angeles County. NHANES data from 1999 to 2004, showed that, compared to national norms, children in

TABLE 1 | Key Strategic Partnership for Interprofessional Collaborative Education in Pediatric Dentistry (SPICE-PD) key evaluation questions and data sources.

Focus area	Evaluation question	Data sources
Program development	What progress has the University of California, Los Angeles team made in establishing and improving SPICE-PD?	Program implementation tracking log Enrollment records Year-end survey of all SPICE-PD participants Faculty interviews Electronic dental/medical records
Learning	To what extent has SPICE-PD helped participants learn core competencies?	Year-end survey of all SPICE-PD participants Year-end SPICE exit exam Board exams
Professional choices	To what extent have SPICE-PD graduates applied core competencies and approaches to their practices?	Alumni survey
	To what extent have SPICE-PD graduates reported an increased commitment and preparedness to serve children from underserved and special needs populations? What proportion of graduates provides services to these children?	Alumni interviews

Los Angeles County were more likely to experience dental caries. In the primary dentition, nearly 40% of preschool children residing in LA County had dental caries compared to 28% of same age children in the US. Children residing in LA County had less favorable oral health than children in the US in 1999–2004 with ethnic minorities having the worst (6).

The program provides culturally sensitive preventive oral health care for children (aged 0–5 years) of low-income families in an integrated medical/dental setting. The objectives of the program include: giving patients access to early intervention in a community health setting, connecting caregivers early with a dental home, providing dental students and dental residents more in-depth pediatric experience, testing and implementing strategies for ECC prevention, and integrating pediatric dentistry with medical and nursing pediatric cohorts. By being located in a primary health-care facility with easy access and medical integration and by having the primary focus on prevention, IOCP helps break the barriers that contribute to disparities in oral health.

The IOCP rotation is part of the mandatory 1-week pediatric dental rotation for all dental students (87 dental students per year). In addition, each year, 12 dental students choose the IOCP 3-month rotation (total hours spent at IOCP in 3 months is 36 h) as a selective. Dental students, pediatric dental residents, international pediatric dental residents, medical residents, and advanced practitioner nursing students all participate side by side at IOCP rotations. The main goals of the IOCP rotation are for multidisciplinary trainees to gain proficiency in:

- Infant oral health exam techniques and procedures;
- Assessing caries risk using CAMBRA and clinical exam results;
- Examining, diagnosing, and treating the oral health needs of very young children;
- Working in a community-based clinical environment and understanding how to integrate infant oral care with the standard care delivered by pediatricians, nurse practitioners, and other providers.
- Understanding the barriers to accessing care for lower income families;
- Delivering perinatal and infant/toddler oral health education to caregivers.

The program has partnerships with Head Start/Early Head Start programs, WIC, and other community organization settings and is also easily replicable into those community settings. The advantage of IOCP is its limited overhead and start-up costs and potential to reduce health-care costs associated with oral disease. Unlike costly restorative/surgical care (21), the IOCP emphasizes education and prevention of dental diseases. This innovative approach helps reduce the burden of social disparities by providing preventive dental services and increased access to infants and toddlers from families of low socioeconomic status. This in turn prevents these families and children from losing valuable hours of work and school to attend to costly, risky, and time consuming restorative dental appointments. Preventive care at a typical IOCP visit includes the following six steps (35):

1. Caries risk assessment using CAMBRA,
2. Proper positioning using the "Knee-to-Knee" exam,
3. Toothbrush prophylaxis,
4. Clinical oral exam,
5. Fluoride varnish application,
6. Anticipatory guidance and self-management goals (using principles of motivational interviewing).

SUCCESS OF IOCP

An IOCP visit includes educating caregivers on early preventive oral health strategies and asking them to select two realistic self-management goals. Caregivers leave the clinic with a recall dental appointment that is based on the child's risk assessment and is usually between 1 and 3 months. The IOCP clinic operates every Wednesdays year-round. From July 2010 to November 2016, IOCP served 950 patients' aged 0–5 years for a total visit count of 2,572. Of the 950 children seen, full data are available on 908 children. Of these, 240 cases (26%) have been maintained with no decay, 38 cases (22% of all kids with white spot lesions) maintained at white spot lesions (and possibly have lesions arrested), and 39 cases (10%) were averted, which means that their white spot lesions were arrested and/or their caries were restored. Only 95 cases (10%) had worsening disease. The successful IOCP program rotation is one piece of the SPICE-PD curriculum that the UCLA pediatric dental residents and selected pediatric medical residents participate in during their residency programs. The goal is to augment and advance existing training to more effectively prepare residents to meet the growing oral health needs of children from underserved, minority, and high-need vulnerable populations.

CONCLUSION

With the creation of IOCP and the addition of the SPICE curriculum, UCLA's Division of Pediatric Dentistry has taken the unprecedented steps to battle the burden of ECC through community-based, evidence driven, and culturally sensitive ways. The comprehensive and progressive SPICE-PD curriculum focuses on teaching pediatric dental residents to effectively address the social determinants of oral health and thereby provide comprehensive care to the patient. At IOCP, dental students and residents learn and practice minimally invasive dentistry to address oral health disease at an early stage. Together, both projects have the potential to deliver better care, improve clinical outcomes, and reduce the overall cost of care and oral health disparities. Establishing an IPE program, in which minimally invasive dentistry is at the core of the curriculum, brings an innovative, systems approach to improve the oral health of the pediatric population through greater prevention and disease management by risk assessment, improvement in oral health literacy, cultural competency, and infrastructure development.

ETHICS STATEMENT

UCLA IRB approval #16-000185.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Interprofessional Oral Health Education Improves Knowledge, Confidence, and Practice for Pediatric Healthcare Providers

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Dental caries is the most prevalent chronic childhood disease in the United States. Dental caries affects the health of 60–90% of school-aged children worldwide. The prevalence of untreated early childhood dental caries is 19% for children 2–5 years of age in the U.S. Some factors that contribute to the progression of dental caries include socioeconomic status, access to dental care, and lack of anticipatory guidance. The prevalence of dental caries remains highest for children from specific ethnic or racial groups, especially those living in underserved areas where there may be limited access to a dentist. Although researchers have acknowledged the various links between oral health and overall systemic health, oral health care is not usually a component of pediatric primary health care. To address this public health crisis and oral health disparity in children, new collaborative efforts among health professionals is critical for dental disease prevention and optimal oral health. This evaluation study focused on a 10-week interprofessional practice and education (IPE) course on children's oral health involving dental, osteopathic medical, and nurse practitioner students at the University of California, San Francisco. This study's objective was to evaluate changes in knowledge, confidence, attitude, and clinical practice in children's oral health of the students completed the course. Thirty-one students participated in the IPE and completed demographic questionnaires and four questionnaires before and after the IPE course: (1) course content knowledge, (2) confidence, (3) attitudes, and (4) clinical practice. Results showed a statistically significant improvement in the overall knowledge of children's oral health topics, confidence in their ability to provide oral health services, and clinical practice. There was no statistically significant difference in attitude, but there was an upward trend toward positivity. To conclude, this IPE evaluation showed that offering an interprofessional course on children's oral health to graduate students in dentistry, nursing, and osteopathic medicine can improve their knowledge, confidence, and practice toward children's oral health and expand their professional goals to include caring for underserved, minority children.

Keywords: oral health, prevention, children, early childhood, interdisciplinary, underserved population/ multicultural

BACKGROUND

Approximately 60–90% of school age children worldwide have experienced dental caries (1). In the United States (U.S.), dental caries are the most prevalent chronic disease in childhood (2). Currently 23% of children from 2 to 5 years of age have dental caries in their primary teeth and the prevalence of untreated caries is 19% (2–4). Children suffer from dental caries at a rate five times greater than asthma in the U.S. (5). To address this public health crisis and growing oral health disparities in children, collaborative efforts among health professionals is critical for dental disease prevention and optimal oral health.

Oral health is commonly defined as the absence of oral disease. In 2016, the Federal Dental International (FDI) Dental World Federation defined oral health more comprehensively. Oral health is the capability to speak, taste, smile, touch, chew, swallow, and express a variety of emotions through facial expressions with confidence and no pain, discomfort, and disease of the craniofacial complex (6).

One of the major contributing factors of oral health disparity is poverty. The U.S. ranks second to last in child poverty in the developed countries (7). In 2008, 4.6 million children in the United States did not receive necessary dental care due to financial hardship (8). In California (CA), approximately 47% of children are growing up in poor families and/or reside in subsidized housing for low-income families (8). Specifically in San Francisco, CA, 40% of children attending schools serving primarily those from low-income households experienced untreated dental caries by the time they entered kindergarten, which is eight times higher than the rate of untreated dental caries in high-income schools (9).

Racial disparities in oral health are also prevalent. In California, Hispanic/Latino (49%), African-American (45%), and Asian (54%) preschool children experience untreated dental decay at rates higher than those of whites (34%) (10). Some racial disparities in oral health can be attributed to cultural differences in feeding and levels of oral health knowledge.

Children are one of the vulnerable and underserved populations that have persistent, systemic obstacles to accessing preventive oral health care (11). As of December 2016, over 35 million children were enrolled in Medicaid (12), a combined state and federal health program to cover medical expenses for individuals with limited income and resources in the U.S. (13). In fiscal year 2014–2015, nearly 5.4 million children aged 0–20 years were enrolled in Denti-Cal, California's Medicaid dental plan, with numbers showing an increasing trend every year (14).

Over five million children in California are eligible to receive dental care through Denti-Cal; however, the majority of them do not utilize the service. According to the Department of Health and Human Services, from October 2014 through September 2015, only 51.8% of children and teenagers with Denti-Cal attended at least one dental visit (15), suggesting that nearly 50% had not seen a dentist. Children without insurance (30.2%) or with public insurance (27.8%) have higher rates of oral health problems compared to children with private insurance (16.8%) (National Survey of Children's Health 2011–2012) (16). Uninsured children were the most likely to have never been to a dentist in their life (18.7%) and those with Medi-Cal were the most likely to have never been to a dentist (15.7%) compared to those with other types of insurances (17).

One of the reasons behind the low utilization rates of Denti-Cal is the limited access to local dentists who accept patients covered by Denti-Cal insurance. In a 2016 report by the Little Hoover Commission, at least 5 out of 58 counties in California had no dentists accepting Denti-Cal and numerous other counties had no dentists who are accepting new Denti-Cal patients (15). California has more dental health professional shortage areas than any other state (18). Some reasons for this low number of dentists willing to provide services to patients with Medicaid are because of the program's low reimbursement rates, frequently missed appointments by patients, and reluctance to treat patients with potentially complex dental issues (9).

Children living in rural areas face greater obstacles in receiving oral health care as many dentists do not live in rural areas where many underserved populations reside (19). Dentists are not evenly distributed geographically (20) and, furthermore, many dentists are not comfortable treating young children under 6 years of age. A 2006 study concluded that a large percentage of dentists did not feel prepared to treat children, especially if the children were very young (21). Professional health sciences schools should be responsible for training graduates to meet the oral health needs of all children. Novel educational programs need to be established urgently to nurture health professionals with the skills and confidence to treat children and to help address the oral health disparity for children.

Unfortunately, recruiting more dental health providers to accept Medicaid and to serve in health professional shortage areas requires policy changes. Recruiting dental health providers will continue to be a challenge in California until changes are made in the Medicaid reimbursement system. According to the Little Hoover Commission, the majority of California's 31,640 professionally licensed dentists, and a sizeable share of those preparing to become dentists, do not intend to participate in Medicaid (15). Currently, only 29% of California dentists participate in the Medicaid program and 42% of dentists participate nationally. These recruitment challenges demonstrate that dentists cannot provide oral health prevention for all children (15).

BACKGROUND AND RATIONALE

Although researchers have acknowledged the various links between oral health and overall systemic health, oral health care usually remains independent from pediatric primary health care (22). In 2011, the Human Resources and Services Administration (HRSA) suggested that primary care practitioners include oral health care services in their primary care practice to help reduce the disparity in preventive dental care for children younger than 5 years old (23). It was suggested that family physicians and pediatric primary care providers should play an increasingly significant role in assessing oral health of children (23). The American Academy of Pediatrics reported that about 90% of infants and children up to 1 year of age have seen a primary care clinician, but less than 2% have been to a dentist (24). These providers may care for a child up to 11 times before the child sees a dentist;

thus, "well child" appointments are ideal opportunities to provide oral health assessments, to apply fluoride varnish, and to educate parents on key oral health messages (24). An example of a missed opportunity is the discrepancy between the recommendation that every infant, toddler, and preschooler have a regular application of fluoride varnish to prevent dental caries; yet, it is reported that only 4% of primary care providers are applying fluoride varnish (24). With training and an understanding of the indications and limitations of topical fluoride application, advanced practice nurses, registered nurses, licensed practical nurses, physicians, physician assistants (PAs), and medical assistants, in some states, are allowed to apply fluoride vanish (24).

Healthy People 2020 is the U.S. government's plan for creating a healthier nation, and some of their objectives are to attain high-quality, longevity free of preventable disease, disability, injury, and premature death; achieve health equity, eliminate disparities, and improve the health of all groups; create social and physical environments that promote good health for all; and promote quality of life, healthy development, and healthy behaviors across all life stages (25). To address these goals, the University of California, San Francisco (UCSF) developed a didactic course with associated clinical experience to train dental care providers and other primary healthcare providers on preventive oral health for young children. Primary healthcare providers can play an essential part and have the chance to counsel their patients on taking their child to the dentist for early disease intervention, especially for young and low-income children (24).

There may be a lack of knowledge about oral health prevention in the care for infants and young children and those with special needs in the training of general dentists, as well as teaching of pediatric providers and other professionals (26). The education and training of dental professionals' focuses on procedures leaving less time for the interprofessional health and/or social issues. It is not possible to address these knowledge gaps without an integration of dentistry with medicine, nursing, and other health professions. Providing children's oral health care is an ethical obligation of dental and other health professionals caring for children and working with parents.

There are a limited number of studies on oral health education programs for primary care providers. One study evaluated an oral health education program provided as part of the curriculum in a Masters nursing program for pediatric nurse practitioners (PNP) to increase the number of primary care providers trained on preventive oral health care for young children, particularly those who do not have access to a dental home. A 1-h lecture was given to 30 PNP students by pediatric dental faculty members and a pediatric dental resident based on the First Smiles and American Academy of Pediatrics content (27). The students also participated in a practicum where they practiced the examination techniques and fluoride varnish applications. Pre-tests and post-intervention tests showed positive changes in the students' knowledge, confidence, and attitudes of oral health skills (28).

Another study consisted of 50 interviews with pediatricians to complete a questionnaire about children's oral health knowledge. The results concluded that there is a need for more communication between the two specialties of medicine and dentistry to deliver better oral health care to children (29). Another study mailed knowledge questionnaires on children's oral health to 464 family medicine program directors and 208 completed the questionnaire. The results showed that less than 30% of the program directors felt comfortable with the application of fluoride varnish. The program directors felt this way because of the lack of knowledge on children's oral health and it was concluded that 95% of family medicine program directors believed oral healthcare knowledge should be a component in the residency training (30).

To help address the oral health needs of young children, an interprofessional oral health course was developed for students in nursing, medicine, dentistry, and osteopathic medicine. The aim of the interprofessional pediatric oral health course was to train health professionals to increase their knowledge of pediatric oral health, increase their clinical competencies in preventive oral health care, educate their pediatric patients and parents on how to maintain good oral health, and to provide primary oral health care to the underserved, vulnerable, and rural communities upon graduation.

MATERIALS AND METHODS

An interprofessional practice and education (IPE) oral health elective course for students in dentistry, nursing, and osteopathic medicine was developed by the UCSF interdisciplinary faculty. The course was offered at UCSF for all graduate students for three quarters; each quarter is 10 weeks. During the summer 2016, we piloted tested the IPE course. Over the subsequent three quarters, the course enrolled students at the UCSF School of Dentistry, UCSF School of Nursing, and Touro University College of Osteopathic Medicine students as one of their elective courses. The students signed a consent form, completed demographic questionnaires before the first class, and completed online questionnaires before and after the course. The UCSF Committee on Human Research approved the study's protocols, consent forms, and evaluation procedures.

The interprofessional elective oral health course included weekly 2-h lectures for 10 weeks. Students were required to attend at least 8 of the 10 sessions to pass the course. The interdisciplinary faculty members are from the UCSF Schools of Dentistry, Nursing, and Medicine. The course covered topics on children's oral health, barriers on access of care, and addressed disparities in oral health and the needs of low-income communities (see **Table 1** of class titles and objectives). Course content was placed on the UCSF learning platform Collaborative Learning Environment website for students to access the syllabus, lecture schedule, lecture slides, articles, resources, and supplementary materials. During the course lectures, students were asked to collaborate in groups of 2–3 on particular oral health issues brought up in the lecture to create an interactive learning environment. Students in the course were from diverse racial and ethnic backgrounds, so collaboration among interprofessional and diverse student groups enriches the class discussion and application to clinical practice. The course also included a clinical component where students observed a pediatric dentist and completed an oral health assessment of a toddler and applied fluoride varnish under the supervision of a dentist. Students were provided with opportunities for community outreach events and clinics they could attend throughout

TABLE 1 | Interprofessional course: children's oral health for primary care providers.

	Topic	Objective
1.	Introduction to Children's Oral Health and Community Dentistry	To define what dental caries is and what it means to be a community health care provider
2.	The Effect of Cultural and Linguistic Competency and Health Literacy on Access to Oral Health Care	To be made aware of different cultures expectations on health care and that health literacy plays a role in accessing care
3.	Physical Assessment of Oral Cavity and Recognition of Abnormalities	To be able to evaluate and recognize pathology in the oral cavity during regular check-up appointments
4.	Caries Risk Assessment and Disease Prevention	To be able to determine if the child is at high risk for developing dental caries and how to prevent dental caries
5.	Anticipatory Guidance in Pediatric Dentistry	To be able to have an oral health conversation with parents
6.	Infant Oral Health Care, Dental Home, and Referral	To be able to refer infants when their first tooth erupts or when they are 1 year old
7.	The Relationship between Children's Oral Health and the Overall Systematic Health	To be able to recognize that oral health is connected to overall health
8.	Oral Health in Special Needs and Vulnerable Children	To be able to care for the special needs children and know how to manage them
9.	Management of Orofacial Trauma and Acute Dental Care	To be able to handle a dental trauma and refer when needed
10.	Case Presentations and Final Assessment	To have open class discussion about what has been taught and answer questions about cases that summarize the course

the 10 weeks to complete the clinical requirements. The students were also given a checklist to complete after participating in the two clinical skills sessions, and proof of participation by the supervising dentist was submitted to complete the course requirements.

To evaluate the interprofessional course four questionnaires were completed before and after the course: (1) course content Knowledge, (2) Confidence, (3) Attitudes, and (4) Clinical Practice. The questionnaires were modified from those used in previously published studies on oral health interventions for primary care providers (28), and the knowledge questionnaire was created by our study team and faculty lecturers.

The course content Knowledge questionnaire included 24 multiple-choice questions. There were two to three questions designed to cover key points from each of the 10 lectures. The knowledge questionnaire was scored as correct (1) or incorrect (0).

The Confidence questionnaire included 10 items to assess the student's level of comfort in providing children's oral health. Each item was rated on a three-level Likert scale, very confident, somewhat confident, or not confident. Responses were coded as 0 for not confident, 1 for somewhat confident, and 2 for very confident. The Cronbach's alpha coefficient, a reliability coefficient that measures the item's internal consistency, was 0.95 for the baseline questionnaire.

The Attitude questionnaire included four questions evaluating the student's attitude toward providing children's oral health. Each item was rated on a four-level Likert scale, strongly disagree, disagree, agree, and strongly agree. The responses were scored as 0 for strongly disagree, 1 for disagree, 2 for agree, and 3 for strongly agree. The Cronbach's alpha was 0.80 for the baseline questionnaire.

The Clinical Practice questionnaire included 10 questions evaluating clinical experience and competence of the students' in providing oral health care to children. Questions 1–3 asked students about how many oral health exams were incorporated into their physical exams, and how many fluoride treatments they performed in the past 3 months. Questions 4–10 asked about "willingness" to perform the items listed. Each item was rated on a four-level Likert scale, frequently, occasionally, rarely, and often. The Cronbach's alpha was 0.93 for the Clinical Practice questionnaire's items 4–10.

The data analysis plan was to calculate frequencies and proportions for categorical variables or mean and SD for continuous variables. The demographic data were summarized for each characteristic. The knowledge, confidence, behaviors, and attitude questionnaires were summarized at the item level and as mean scores and compared pre- and post-course. A Wilcoxon ranked test was calculated to compare responses for the pre-test and post-test for mean scores not normally distributed. In order to investigate any change in responses to the individual questions from the pre- to the post-course, the exact McNemar's test was calculated for dichotomous or categorical responses. Non-parametric and crosstabs were calculated with chi-square analyses.

RESULTS

A total of 41 students were enrolled in the IPE oral health course over the three quarters. Some of the students did not complete the baseline questionnaire ($n = 6$) or dropped out of the course ($n = 4$) and were excluded from the analysis. In the end, there were a total of 31 students who completed the pre- and post-intervention questionnaires as well as all of the requirements of the intervention. There were 25 students (80%) from the UCSF School of Dentistry (80%), 3 students (10%) from the UCSF School of Nursing, and 3 students (10%) from the Touro University College of Osteopathic Medicine.

The majority of students (**Table 2**) were between 20 and 21 years of age (78%), female (73%), Asian (61%), and first-generation college students (51%). Twenty seven percent of the students were from underrepresented minority groups and 29% were from disadvantaged backgrounds.

Oral Health Knowledge

Sixty-three percent of the students stated they had formal training in oral health prior to IPE oral health course. The students' oral health knowledge significantly improved from the pre-to the post-tests [mean (SD) = 15.10 (2.09) and 16.58 (2.90), respectively pre- and post-tests; Wilcoxon signed ranks test, $p = 0.005$], with a moderate effect size (Cohen's $d = 0.59$) (**Table 3**).

The two items that had statistically significant increases in knowledge from the pre- and post-tests were: (1) when to use fluoride (from 58 to 84%) and (2) when to perform infant

TABLE 2 | Students' demographic characteristics.

Characteristic	Category or response	*N* (*N* = 41)	%
Age (in years)	20–29	32	78
	30+	9	22
Sex	Male	10	24
	Female	31	76
Race	White	6	15
	Hispanic or Latino	5	12
	Asian	25	61
	Black or African-American	3	7
	More than one race	2	5
Ethnicity	Hispanic or Latino	8	20
	Not Hispanic or Latino	33	80
Family yearly income	Less than $10,000–$49,000	14	34
	$50,000–$99,999	14	34
	$100,000 to more than $150,000	13	32
First-generation college student	Yes	21	51
Scholarship	Yes	29	71
Financial aid	Yes	25	61
Loan	Yes	29	71
Underrepresented minority	Yes	11	27
Disadvantaged background	Yes	12	29
Rural residential background	Yes	8	20
Primary language	English	32	78
	Spanish	1	2
	Mandarin	4	10
	Other	4	10
Location of birth	California, USA	17	42
	Another state in USA	5	12
	Another country than USA	19	46

frenectomy (from 27 to 73%) (McNemar test $p < 0.008$, $p < 0.001$, respectively). However, at the post-test less than 50% of the students correctly responded regarding; what is the first thing to assess in oral assessment (30%), what is main oral health problem in special needs patients (13%), and how many children six and under see a dentist (20%).

Confidence

There was a statistically significant increase in the students' confidence in their ability to provide oral health services from the pre- versus post-course completion with a strong effect size [mean (SD) = 13.13 (5.89) and 17.09 (4.02), respectively, $p < 0.001$; Cohen's $d = 0.79$] (**Table 4**). There was a statistically significant positive improvement in confidence for these content areas: consulting on fluoride supplements ($p = 0.004$), consulting during dental visit during infancy/childhood ($p = 0.019$), examining teeth of infants and toddlers for tooth decay ($p = 0.028$) and identifying tooth decay in early childhood ($p = 0.001$). Unfortunately, two students were not confident in knowing when to refer a child to the dentist. There was an overall decrease in the percentage of responding "not confident" on the pre-test compared to the post-test.

Attitude and Clinical Practice

Overall there was an increase in the students' positive attitudes about oral health knowledge from the pre- versus post-course, but it was not statistically significant and had a weak effect size [mean (SD) = 11.10 (1.45) and 11.32 (1.30), respectively, Cohen's $d = 0.16$] (**Table 5**). There was a statistically significant difference in the response to the item: prescription of fluoride supplements when indicated ($p = 0.028$). The scores increased positively toward providing oral health care to children. Most of the students wanted to provide preventive oral health care, but one student showed a lack of confidence in providing routine dental check-up at well child visits when starting practice.

There was an overall statistically significant with a moderate effect size increase in students' clinical practice skills from the pre- versus post-course [mean (SD) = 7.87 (7.39) and 11.40 (6.85), respectively, $p = 0.005$, Cohen's $d = 0.50$] (**Table 5**). The students became more aware of providing oral health care to children after the IPE oral health course. There was a significant increase in the number of oral health assessments provided during physical exams in the past 3 months ($p < 0.001$), and applying fluoride varnish applications during routine exams ($p < 0.001$). There was also a statistically significant increase in counseling parents on the importance of regular dentist visits ($p = 0.016$) and referring high-risk patients to a dentist ($p = 0.011$). There were 15 students who lacked confidence in prescribing fluoride and 10 students who lacked confidence in asking about the child taking a bottle to bed.

DISCUSSION

This study's objective was to evaluate changes in student's knowledge, confidence, attitude, and clinical practice in children's oral health after completing an interprofessional practice and education course on children's oral health. The majority of students (63%) had some type of oral health education before the course; yet, there was an overall increase in knowledge after the course. Most of the students did not have the baseline knowledge on when to use fluoride (58%) and when to perform a frenectomy (27%) on an infant. The student's pre-course knowledge showed that less than half the students knew what to assess first in an oral examination (oral tissues) (30%), had a lack of knowledge about providing oral health care for special needs patients (13%), and knew about the limited access to dental care for children living in low-income families (20%).

The confidence for the IPE course was noteworthy because the majority of students were confident in the pre-test before the course, but they became even more confident after completing the oral health course. The curriculum in the course created a significant change ($p < 0.001$) in the overall confidence of the students. There was also an almost 50% increase in students in identifying oral pathology after the curriculum was completed from 13 students to 22 students, although the results were not statistically significant. The overall "not confident" response for all questions decreased, which showed a positive trend to an overall increase in their confidence to perform more oral health procedures and deciding what treatment to provide.

Students' attitudes about how they felt about pediatric oral health and its overall importance increased although it was not

TABLE 3 | Level of students' knowledge pre- and post-course.

	Knowledge questions	Total number	Pre-test		Post-test		
			Number correct	%	Number correct	%	*p*
1.	In normal dentition, how many primary baby teeth do children have?	31	30	97	28	90	0.500
2.	What is the #1 chronic childhood disease?	31	28	90	31	100	0.250
3.	Which is the right sequence of eruption in primary teeth?	26	18	69	15	58	0.453
4.	What is poor oral health associated with?	31	27	87	28	90	1.000
5.	According to the academy of General Dentistry, what percentage of all systemic disease produces oral signs and symptoms?	30	7	23	10	33	0.508
6.	What is the most common presentation of incipient caries without cavitation?	26	22	85	24	92	0.625
7.	Which permanent teeth erupt first?	31	24	77	21	68	0.453
8.	Which teeth in permanent dentition are most common site for caries?	26	26	100	25	96	1.000
9.	What is one of the top 10 greatest public health achievements?	31	27	87	28	90	1.000
10.	First thing to assess in oral exam?	30	16	53	9	30	0.092
11.	What can be used as a sugar substitute in dental cavity prevention?	31	30	97	31	100	1.000
12.	Which snack is least harmful to teeth?	31	23	74	21	68	0.500
13.	By what age should a child first see a dentist?	31	27	87	30	97	0.375
14.	By what age can parent use fluoride toothpaste?	31	18	58	26	84	0.008*
15.	How long should one exclusively breastfeed?	31	19	61	14	45	0.180
16.	What is vertical transmission of bacteria?	31	29	94	29	94	1.000
17.	What is the most common indication to perform a frenectomy in infants?	26	7	27	19	73	<0.001*
18.	What is the major oral health issue with special needs patients?	31	6	19	4	13	0.688
19.	Why may oral hygiene in special needs children be inadequate?	31	30	97	29	94	1.000
20.	How many times a year should one visit the dentist?	31	25	81	29	94	0.219
21.	According to healthy people 2020 how many people are low health literacy?	31	17	55	20	65	0.549
22.	According to Medicaid, low literacy is what reading level?	31	12	39	14	45	0.774
23.	What is oral health literacy dependent on?	31	19	61	23	74	0.344
24.	According to Academy of Pediatric Dentistry, what percent of children under 6 see a dentist?	30	4	13	6	20	0.754
	Total score	**Total number**	**Mean (SD)**	**Median**	**Mean (SD)**	**Median**	***p***
		31	15.10 (2.09)	16.00	16.58 (2.90)	17.00	0.005*

*$p<0.05$.

TABLE 4 | Level of students' confidence pre- and post-course.

	Confidence	Pre-test						Post-test						*p*
		Very confident (2)	%	Somewhat confident (1)	%	Not confident (0)	%	Very confident (2)	%	Somewhat confident (1)	%	Not confident (0)	%	
1.	Consult on child's oral hygiene	15	47	16	50	1	3	26	81	6	19	0	0	0.191
2.	Consult on water fluoridation	16	50	13	41	3	9	28	88	4	13	0	0	0.090
3.	Dietary consult to prevent early childhood tooth decay	18	56	11	34	3	9	28	88	3	9	1	3	0.365
4.	Consult on fluoride supplement during infancy/childhood	12	39	15	48	4	13	25	81	6	19	0	0	0.004*
5.	Consult on dental visits during infancy/childhood	21	66	9	28	2	6	26	81	6	19	0	0	0.019*
6.	Examining teeth of infants and toddlers for tooth decay	17	53	9	28	6	19	20	63	10	31	2	6	0.028*
7.	Identifying tooth decay in early childhood	13	41	12	38	7	22	22	69	8	25	2	6	0.001*
8.	Identifying other signs of oral pathology	9	28	12	38	11	34	20	63	7	22	5	16	0.105
9.	Evaluating the risk of tooth decay in infants and toddlers	15	47	8	25	9	28	25	78	6	19	1	3	0.064
10.	Deciding if the child needs referral to a dentist	15	48	10	32	6	19	22	71	7	23	2	6	0.075
	Total score	Mean (SD) = 13.13 (5.89); Median = 14.00						Mean (SD) = 17.09 (4.02); Median = 19.00						<0.001*

*$p<0.05$.

statistically significant. Since the majority of students had some oral health knowledge, the majority found oral health to be important and they had a positive attitude about providing oral health care. The students' clinical practice had an overall significant increase in routine oral assessments over 3 months. The response of "never" decreased after the intervention, but unfortunately it

TABLE 5 | Level of students' attitudes and clinical practice pre- and post-course.

		Pre-test				Post-test				
	Attitude	**Strongly agree (3)**	**Agree (2)**	**Disagree (1)**	**Strongly disagree (0)**	**Strongly agree (3)**	**Agree (2)**	**Disagree (1)**	**Strongly disagree (0)**	***p***
1.	Routine assessment for early signs of dental problems (e.g., dental decay, gingivitis) during the physical exam	24	7	0	0	27	3	1	0	0.144
2.	Referral to dentist by 1 year of age	22	9	0	0	26	5	0	0	0.096
3.	Counseling on the prevention of dental problems (e.g., dental decay, gingivitis, trauma)	26	5	0	0	28	3	0	0	0.394
4.	Prescription of fluoride supplements when indicated	25	5	1	0	23	8	0	0	0.028*
	Total score	Mean (SD) = 11.10 (1.45); Median = 12.00				Mean (SD) = 11.32 (1.30); Median = 12.00				0.393
	Clinical practice	**0**	**1–10**	**11–20**	**21+**	**0**	**1–10**	**11–20**	**21+**	***p***
1.	Approximately how many routine physical exams have you performed over the past 3 months?	23	3	2	4	20	7	3	2	<0.001*
		0	**1–5**	**6–10**	**11–15**	**0**	**1–5**	**6–10**	**11–15**	***p***
2.	Approximately how many oral health exams have you included in your routine examinations in the past 3 months?	11	10	5	6	6	10	4	12	0.204
			Yes	**No**			**Yes**	**No**		***p***
3.	Have you applied fluoride varnish as part of your routine examination to children in past 3 months?		14	16			26	4		<0.001*
		Frequently (3)	**Occasionally (2)**	**Rarely (1)**	**Never (0)**	**Frequently (3)**	**Occasionally (2)**	**Rarely (1)**	**Never (0)**	***p***
4.	Assess a child's fluoride intake to determine the need for supplementation	6	4	3	17	11	6	6	7	0.198
5.	Prescribe a dietary fluoride supplement	6	2	3	17	6	3	4	15	0.266
6.	Discuss the use of fluoride toothpaste with parents	8	9	2	11	12	9	4	5	0.406
7.	Inquire whether a child is taking the bottle to bed	5	5	8	12	9	8	3	10	0.132
8.	Counsel parents on the importance of going to a dentist on regular basis	11	4	4	11	15	7	4	4	0.016*
9.	Inquire about mother's dental health	6	2	5	17	9	6	7	8	0.105
10.	Referred a high-risk patient to a dentist	8	1	7	12	10	7	4	7	0.011*
	Total scores (for 4–10 items above)	Mean (SD) = 7.87 (7.39); Median = 8.00				Mean (SD) = 11.40 (6.85); Median = 11.00				0.005*

*$p<0.05$.

was still a response for some of the clinical practice questions. Some students were not confident in prescribing fluoride in clinical practice (54%). Future studies should incorporate a mechanism to include feedback about the clinical skills practice to identify ways to encourage more positive attitudes in clinical practice. These findings are similar to an earlier study at UCSF on Oral Health Education for Pediatric Nurse Practitioner Students (28). There was an overall increase in knowledge, confidence, attitude, and clinical practice after completing the curriculum on children's oral health, but this was not an interprofessional course (28).

A recent study aimed to assess the usefulness of an IPE clinical simulation and case study experience for nurse practitioner (NP)/midwifery (MW), medical, and dental students using oral systemic health and they included self-reported completion of interprofessional competencies (31). A total of 318 students participated in the IPE experience in 2013 and 300 students in 2014. The three-day experience included 100 NP/MW, dental, and medical students participating each day. Before the pre-test and IPE experience, the researchers asked the participants to complete two modules (The Relationship of Oral to Systemic Health and The Oral Examination) and to watch a 9-min video about the IPE competencies. During the standardized patient encounter, teams of four students (one NP or MW, one dental, and two medical students) met in a simulation center exam room with one standardized patient. There was a 60-min session that was facilitated by an NP/MW or MD faculty member; a DDS facilitator toggled between two exam rooms. The physical examination of three organ systems: oral, cardiac, and pulmonary was addressed in the session. All students had a faculty-facilitated session that helped them prepare to provide their respective teaching/teach-back element of the experience. The dental student taught the oral exam, the NP/MW student taught the pulmonary exam, and the medical student taught the cardiac exam, with teach-backs by each student. There was a statistically significant change in student's mean scores from pre-test to post-test. The faculty facilitators completed a post-test encounter questionnaire that assessed their attitudes about IPE and the value of the IPE experience and the trained faculty facilitators across disciplines reported a high level of agreement that IPE positively influenced students' interprofessional communication, collaboration, patient communication, and understanding of professional roles and responsibilities. The study findings also supports that oral systemic health IPE is a positive intervention for facilitating medical–dental collaboration and interprofessional training, particularly in oral health promotion and disease prevention. This study had similar findings to ours, but with a different approach in methodology. In this study, each student taught the specifics of their respective fields, while our study included collaboration and discussions among the students as a part of each lecture and during clinical experiences.

The most recent study by Berkowitz and colleagues developed an interprofessional curriculum in partnership with a dental school to teach oral health in the primary care setting to Physician Assistant (PA) students in order to measure the impact of a curricular model that would be easy to adapt across academic settings (32). Twenty-three students over three semesters attended didactics in the classroom, participated in a clinical skills lab, observed in the dental clinic, and observed organized clinical examinations, which were used to teach oral health to first-year PA students. Pre- and post-intervention test results concluded that a short, concentrated amount of instructional time in oral health curriculum had a substantial impact on the retention rate of oral health knowledge for the PA trainees and students express enthusiasm to begin using oral health skills. A concentrated interprofessional oral health program can be successfully integrated into academic settings with an optimistic effect on knowledge and improved patient oral health care. This study is very similar to ours, but it lacks the clinical component that encourages students to provide oral health exams and treatment. This study's conclusion presented parallel findings. Interprofessional practice and education on oral health will raise awareness in primary care providers and encourage more oral health treatments and timely referrals.

Although this is a novel course, including didactic, discussion, and clinical practice, there were limitations to the study results. There was no control or comparison group who did not participate in an interprofessional oral health course. There were also many correct knowledge responses during the pre-test that could be due to the majority of the students who had some type of oral health education prior to the intervention. The curriculum could be modified to expand the students' knowledge rather than reinforce knowledge. The small sample size limits our ability to find statistically significant findings yet the course is ongoing so in a few years there will be over 40 more students enrolled in the course. This sample size also limited the ability to compare results in relation to the broader population of health professional students. It is not clear if the changes that occurred as a result of the course would not have occurred without the IPE component. It was not possible to identify differences in knowledge gained by discipline (i.e., dentistry, nursing, medicine).

The interprofessional course included some unique components that helped make it successful. The faculty who taught in the course were from the UCSF Schools of Dentistry, Medicine, and Nursing. The courses in the current nursing and dental curriculum do not consistently include faculty from different disciplines; therefore, this course provided a unique experience and exposure to interprofessional practice and education not included in their traditional program. In addition, the clinical experience for the nursing students was enriched since they attended a dental clinic with a dentist and learned how to conduct an oral health assessment along with dental students. Likewise, the dental students had never attended a clinical practicum with nursing students. There are several studies that showed health professional students exposed to interprofessional clinical and educational experiences are more likely to hire or work collaboratively with professionals from other disciplines after their training (28, 32).

This project includes a follow-up study that will track the students over 5 years to learn about their clinical practice and evaluate if they are using the knowledge gained from participating in the IPE oral health course. Over time, we may be able to determine if and how the course impacted the student's clinical behavior after graduation.

CONCLUSION

To conclude, this study showed that offering an interprofessional course on children's oral health to graduate students in dentistry, nursing, and osteopathy can improve their knowledge, confidence, and practice toward children's oral health and expand their professional goals to include caring for underserved, minority children. The pre-test response results displayed their lack of knowledge and confidence in providing oral health care to children. After the course, the majority of the students increased their oral health knowledge and confidence toward providing oral health care to children. Although overall clinical practice behaviors improved, there were still some students who were not ready to provide oral health care to children. Primary care providers are on the forefront of being able to provide anticipatory guidance to parents. They anticipate changes in children's oral health needs based on the children's developmental stages (26). Parental dependency, demographic, and environmental context also play a key role in predicting what a child may need for oral health care, and primary care providers are on the forefront to help with oral health prevention through anticipatory guidance to improve oral health outcomes (26). The primary care provider plays an essential role in addressing oral health disparities for young children in the U.S. (20). This course provides students with a foundation for collaborative practice in the community to increase awareness of their respective fields and decrease oral health disparities. Healthcare providers are encouraged to participate in interprofessional practice and education courses and to collaborate across disciplines to deliver high-quality oral health care.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the UCSF Committee on Human Research with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the UCSF Committee on Human Research.

AUTHOR CONTRIBUTIONS

DC: lecturer for the course, wrote the manuscript, and worked on the team to develop the evaluation measures, collected measures, and analyzed the data. JK: worked on the team to develop the evaluation measures, developed the online data collection measures, analyzed the data, and reviewed the manuscript. KD: lecturer in the course, developed course objectives for her lecture, and reviewed and edited the final manuscript. RS: lecturer in the course, developed course objectives for his lecture, and reviewed the manuscript. BL: principal investigator on the HRSA grant, developed course objectives for his lecture, lecturer in course, and reviewed the manuscript. AA: lead on the evaluation project, designed the evaluation, supervised and led the analysis team, and edited the final manuscript.

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Strategies for Meaningful Engagement between Community-Based Health Researchers and First Nations Participants

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The Baby Teeth Talk Study (BTT) is a partnership-based research project looking at interventions to prevent early childhood caries (ECC) in First Nations populations in Canada. Community-based researchers (CBRs) conducted preventive and behavioral interventions that targeted expectant mothers and their newborns, over a 3-year period. The work of the CBRs requires a great deal of training and skills to administer the interventions. It also requires a broad set of strategies to meaningfully engage participants to make health-promoting changes in their behavior to prevent ECC in their children. After implementing the intervention, BTT CBRs participated in interviews to explore the strategies they employed to engage participants in the prevention of ECC. CBRs perceived two key strategies as essential for meaningful engagement with BTT participants. First, CBRs indicated that their shared experiences through motherhood, First Nations identity, age, and childhood experience provided a positive foundation for dialog with participants that lead to build trust and rapport. Second, supportive interpersonal and culturally based communication skills of the CBR provided further foundation to engage with participants from a strength-based approach. For example, the CBRs knew how to effectively communicate in ways such as being gentle, non-intrusive, and avoiding any perception of judgment when discussing oral health behavior. In First Nations health research, CBRs can provide an essential link in engaging participants and the community for improvements in health. Researchers should carefully consider characteristics such as shared experience and ability to understand cultural communication styles when hiring CBRs in order to build a solid foundation of trust with research participants.

Keywords: community research, interpersonal communication, cultural communication, early childhood caries, first nations health research

INTRODUCTION

Community-based participatory research has emerged as a preferred approach to health research with First Nations, Inuit and Métis people (FNIM) (1). The emphasis on involving researchers who are directly from the participating community is a critical component to meaningful engagement with research participants and the community. In First Nations health research, the engagement between participants and researchers has resulted in the common practice of hiring community research assistants (2, 3). The shifts in control in First Nation's research has resulted in much more participatory, collaborative and in some cases community driven research. The role of the community research assistant has also transformed and their participation begins in the initial design of the research as well as in the analysis of findings. The Baby Teeth Talk project (BTT) (as described below) has embraced this shift in research and employs a Community-Based Researchers (CBRs) approach. In many cases, CBRs have experience in community-based participatory research and often receive further specialized training specific to the project. CBRs are often well equipped to engage in research. In other cases, however, the opportunity to recruit experienced CBRs does not exist, and research projects recruit non-First Nations CBRs.

The Baby Teeth Talk Study is an example of a project employing both First Nations and non-First Nations CBRs. BTT is a tri-country project with Canada, New Zealand, and Australia focusing on four successive interventions to address the high prevalence of early childhood caries (ECC) in Indigenous populations worldwide (4, 5). ECC is characterized as the presence of tooth decay in children aged 5 years or younger (6). The interventions include offering dental care during pregnancy, applying fluoride varnish to the teeth of infants at 6, 12, and 18 months, and using motivational interviewing (MI) and anticipatory guidance to counsel mothers on caring for their children's teeth (7).

There are two critical elements of community/researcher engagement in this research. The first is the development of partnership-based relationships with the First Nations community partners such as Health Divisions or primary health care providers, which includes adapting the research methods to the sociocultural needs of the community, specifically in the areas of implementation planning at the local level and the dissemination of findings. The second critical engagement component of this research is the enhancing local research skills by hiring and extensively training CBRs to carry out the interventions and collect all the data. To this end, the BTT CBRs attended training sessions held every year in the counseling technique of MI, led by certified experts in MI. This was followed by monthly coaching calls with the MI experts, as well as training sessions on oral health anticipatory guidance, the application of fluoride varnish, and data collection and entry.

In order to enhance and document our methodology, the investigators decided to explore strategies that the BTT CBRs (1) used to establish and maintain relationships with the participants and (2) those that supported effective data collection. This paper describes the experiences of the BTT CBRs in conducting research in the community and their strategies for relationship building with participants during data collection. The focus is not on the BTT participants, but on the experiences of CBRs in the BTT study.

BACKGROUND

Health research in First Nation, Inuit and Métis (FNIM) communities has been a challenge both for communities and for the academics conducting research. For communities, a long history of poorly implemented research has resulted in a narrative of negative researcher/community relations with little positive impact or improvement in health conditions for FNIM people (8). However, research in FNIM communities has evolved in recent years. Collaborations between communities and scholars provide many positive examples of the transformation of research in these communities (8). The increasing movement away from curiosity-driven research has resulted in an increasing body of literature and research projects focused on the needs of the community in tandem with the interests of academics. The emergence of Indigenous methodologies are also partially the result of an increasing number of FNIM people completing advanced degrees and contributing important innovations to scholarship. It is also due to the impact of the global Indigenous self-determination movement working at local, national, and international levels. Indigenous methodologies are also being utilized as a more appropriate way of engaging communities in research processes that are reflective of local cultures and traditions of knowledge gathering. This important shift has resulted in a foundational debate on the validity and value of Indigenous methodological frameworks and appropriateness of tools to understand Indigenous cultures and inter-cultural social processes.

Wilson (9) describes the recent phase of Indigenous research taking place that coincided with global Indigenous movements. In Canada, this culminated with the Royal Commission on Aboriginal People (RCAP) report in 1996 and laid the important groundwork for this new phase of research that critically examined the impacts of residential schools, the mass adoption of FNIM children out of their communities in the 1960s, and the negation of treaties through natural resource extractive activities. Social activists of both FNIM and non-FNIM people embarked upon this type of research resulting in the creation of an extensive set of recommendations that sought to redress the unequal structural relations of FNIM people to the Canadian government and society. The First Nations Regional Longitudinal Health Survey was conducted in 1997 in response to the recognition that health and well-being information was lacking from major national health surveys and that First Nations and Inuit need to control their own data (10). This was designed and delivered for First Nations, by First Nations people (the Inuit withdrew their participation and developed their own survey tool). Indigenous scholars worldwide began to emerge strongly during this period and with it, the introduction of Indigenous methodologies, most notably in the work of Maori scholar Linda Tuhiwai Smith (11).

Shifts in Research Control

Indigenous paradigms in the academy took a further shift with the release of *Decolonizing Methodologies: Research and Indigenous*

Peoples (11) where western methods of inquiry were challenged as perpetuating ongoing colonization of Indigenous peoples across the globe. Smith (11) questions the assumption that research and research methods are "culture free" or "value free" and that researchers occupy a moral high ground of objectivity. This important contribution to legitimizing indigenous research methodologies has influenced the current stage of indigenous research. Presently, Indigenous scholars are openly acknowledging and illuminating their Indigenous worldview using their own data collection methods and research paradigms (9). Brant Castellano's (12) article on the research ethics published in the inaugural edition of the Journal of Aboriginal Health, paved an important path to exploring the rigor placed on scholars who wish to research in FNIM communities. First Nations scholars, like Castellano are now using the academy as a way to explore their own cultural pedagogy and challenge historical assumptions. Scholars today are taking direction from FNIM communities on research topics that are pertinent and contribute to self-determination. This is a marked shift from the earlier phases of research on FNIM people, which sought to control and assimilate individuals and whole communities into the mainstream.

In Canada, the movement toward more appropriate research ethics practices has also shaped Indigenous health research. At the government funding level, the Tri Council Policy Statement: Ethical Conduct for Research Involving Humans, Chapter 9: Research Involving First Nations, Inuit and Métis People of Canada (1) has provided an important framework for conducting respectful research with FNIM communities and individuals. In health research, the Institute of Aboriginal People's Health, which is one of the 13 institutes of the Canadian Institute of Health Research, focusses on meaningful research that addresses the health needs of the community. On a community level, many First Nations communities have established their own research offices that provide a variety of functions including research ethics specific to the community, community approval, and assistance with research. For example, Six Nations of the Grand River in Ontario has a research ethics committee with their own set of research ethics principles guiding how researchers and the community interact in projects (13). First Nations communities in Manitoulin Island (Ontario) have established a similar set of principles and research review committee called the Manitoulin Anishinabek Research Review Committee (14). In Manitoba, the Chiefs in Assembly in 2007 formally committed to self-determination in respectful research relationships by embedding three principles: (i) free, prior, informed consent (on individual and collective levels); (ii) First Nations Ownership, Control, Access and Possession (OCAP™) principles of ownership, control, access and possession of their own data, and (iii) First Nations ethical standards (15).

Research Skill Enhancing or Building in the Community

One important aspect of the OCAP™ principles includes enhancing or building research skills in the community. The nature of academic research has followed the typical trajectory of an academic lead investigator, with graduate students and in some cases undergraduate students collecting and analyzing data, and in other cases, the recruitment of local key informants or community members to assist with the research. However, in FNIM communities, the role of community members as ancillary to the research process has diminished and instead taken center stage. As the OCAP™ principles reinforce, the power relationship between the academic community and the FNIM community has now shifted and the responsibility of the researcher in providing services such as training, employment and community skill building in research are now an increasing requirement for communities to even consider participation in research. As Jacklin and Kinoshameg (16) describe the process of including community members as members of the research team is critical in the development of research tools, as well as the actual data collection because it makes "participants feel confident in the promise of complete confidentiality" (16) (p. 57). In reference to Australian Aboriginal researchers, Laycock (17) states that community capacity building to do health research resulting in practical and positive change requires "being serious about building quality training and offering real support for Indigenous researchers" (17) (p. 9).

Insider Research

Laycock (17) also describes some of the complexities associated with insider research. In many cases, researchers may anticipate that Indigenous researchers are ideally situated to "open doors" in Indigenous communities; however, this is a simplistic and an unreasonable assumption that does not take into account extra pressure on inexperienced researchers. Issues such as family background, kinship links, gender, political connections are another layer of expectations that Australian Aboriginal researchers are burdened with that non-Indigenous researchers do not experience (18).

The role of mutual ethnicity as a point of connection for researchers is a central component of the native insider approach because it also provides a source of "crucial responsibility…in doing this type of research" (19) (p. 220). When there is no shared identity between the researcher and the respondents, other points of connection still coincide with the native insider approach. As Goldade (20) describes having a newborn baby brought along in the interviews made recruiting participants less challenging, and helped "knock down trust barriers, thus smoothing the work of eliciting narratives on sensitive, yet pertinent topics confronting my informants around reproduction, reproductive health, and motherhood" (20) (p. 53).

Community researchers in rural and remote communities are also faced with different challenges than those in larger urban centers. Fears from participants about lack of confidentiality from "insiders" or CBRs from the FNIM community are common in many small communities but are also symptomatic of larger issues of lateral violence, which plague many communities. The effect of lateral violence is expressed in various ways such as gossip, perpetual social infighting, suspicion, and mistrust of others (21). This is compounded in reserve communities where people are further physically and socially isolated and certainly can impact the success of research projects.

METHODOLOGY

In the BTT Study undertaken in Manitoba and Ontario, each individual community engaged in a process of relationship and trust building through pre-existing relationships with the principal investigator of the BTT study (HPL) and co-investigators (22). The hiring of community researchers or CBRs, who in most cases were First Nations people from the communities was also critical in promoting the research project. Due to the nature of the research, significant training with the CBRs has been an ongoing process to ensure that the intervention methods being utilized were consistent between research sites as well as building the necessary research skills for CBRs.

A key component of this research project has been the CBRs. In each community, a CBR was hired to deliver the interventions and collect the data. In most cases, the CBRs are from the communities and are First Nations (six out of eight of the CBRs). In cases where the CBRs are non-First Nations (two of the eight CBRs), they have a significant connection to the community or have an understanding of the larger social and cultural determinants of health where First Nations are concerned. In all cases, CBRs were initially provided with training in the research methodology and were physically gathered together for ongoing training every year for 3 years. In addition, training continued through the use of conference calls with a trainer, as well as updates with the Principal Investigator.

The BTT project takes a participatory approach in recognizing how the relationship between the investigators, the CBRs, and the BTT participants are realigned. BTT CBRs come to the project with their own theoretical and experiential knowledge, which has helped to shape the success of retaining our BTT participants by engaging in authentic relationships. The research also hinges on the development of authentic research relationships (23), which requires meaningful and collaborative relationships so the investigators can learn enough about the community to interpret and analyze the data respectfully and appropriately. A key element of this is our CBR who are the lens in which we understand the experiences of BTT participants. The critical nature of the CBRs in this project renders it important to explore their experiences in the project to understand the strategies they use to engage with participants. A separate research project was subsequently undertaken to explore these strategies and approaches. Research ethics approval was obtained through the home institution of the interviewer and co-investigator from the University of Winnipeg Research Ethics Board for this particular research.

The participants were informed by email by the BTT Principal Investigator of the request to be interviewed and were informed that their participation was not mandatory and there would be no expectation to participate. Despite this, all eight CBRs at the time contacted the BTT PI and volunteered to participate. An experienced Indigenous qualitative researcher and coinvestigator on the BTT project conducted semi-structured individual interviews with all of the eight of the CBRs. A semi-structured or conversational approach was used because of the open-endedness and ability for the interviewer to delve into topics that may not have been anticipated and bring out how the interviewees themselves understand and interpret issues and event (24). This approach is important in conducting these interviews because it provides the necessary environment for the participant to have a large amount of control over what they choose to discuss and the emphasis they would like to place on these particular topics.

Interviews were conducted either on the phone or in person. Interviews were typically an hour in length and were audio recorded, and transcribed. All of the participants were familiar with the interviewer/coinvestigator through the training sessions. Consent was obtained prior to the commencement of the interview. When the interviews were not face-to-face, the consent form was read out loud and participants indicated their agreement to participate and it was noted in written format that oral consent was received. Written consent was obtained for the two interviews that were conducted face-to-face. The interview questions focused on issues of trust with participants and the role of being a First Nations or non-First Nations researcher in the area of FNIM health. Specifically, topics explored included: the importance of working in the area of FNIM health for the CBRs, challenges, and opportunities of being a First Nations person and working in the community, trust as an issue for both researchers and participants, and the importance of having a dental health background in this research.

The interviews were transcribed verbatim and returned to all of the participants to ensure that information was correct. Utilizing the principles of grounded theory, an initial coding framework was developed by the lead author and interviewer (Jaime Cidro) immediately after conducting the interviews. This initial coding, a focus on actions rather than themes and topic was developed to avoid the tendency of making "conceptual leaps" and "adopt extant theories" prior to the analysis (25) (p. 117). Three qualitative researchers then tested the initial coding framework independently by reviewing all the transcripts. The researchers then evaluated the fit and usefulness of the codes (26) and adjusted the framework accordingly. The research team independently coded all the transcripts using a selective approach to identify codes that appeared frequently and seemed most revealing as it pertained to the original research question (27). The research team reviewed all independently coded transcripts together and any outstanding inconsistencies were identified and discussed. The research team engaged in constant comparison between the categories as well as with the other authors, which entailed "sensitivity to differences between emerging concepts/categories" (26) (p. 515). Agreement was reached at all points where inconsistencies were noted.

A draft copy of this paper was sent to the CBRs as a way to ensure trustworthiness. Participants were asked to review the draft paper to ensure that the authors interpreted the social reality of the CBRs in their interviews accurately. Member validation is an important part of confirming the account is consistent with the ways the participants see the world (27).

LIMITATIONS

The BTT CBRs are used to working one on one with expectant mothers and her children in a face-to-face setting. They develop relationships by sharing considerable periods of time talking about in-depth personal issues relating to oral health and infant

development. However, when interviewing the BTT CBRs, the majority of interviews were conducted over the phone, which may have influenced the ability of the CBRs to provide thorough responses. The CBRs were provided with a copy of the interview questions in advance to allow for time to reflect on their responses. Out of the eight CBRs interviewed, two were not First Nations. Early discussions were held to determine whether excluding the non-First Nations CBRs would provide us with a clearer explanation of the experiences of CBRs; however, it was determined that the two non-First Nations CBRs had considerable experience working in a First Nations/FNIM community, and while not "members" still had some important experiences to share.

RESULTS AND DISCUSSION

All eight of the CBRs revealed an intense dedication to working with participants in their communities. Two themes that emerged with all the CBRs included the use of shared experience as a foundation to develop trust and establish rapport, and the use of cross cultural communication to build relationships. Both of these themes are discussed using the voices of the CBRs directly.

Shared Experience

The Baby Teeth Talk Study participants were all women and started out in the research project while they were pregnant, which provided an important foundation for the development of shared experiences with CBRs. Meaningful engagement with participants was most prominently established by having commonalities. For example, all of the CBRs were women and most of them have children, including newborns and infants, which provided a good foundation for connecting with the female participants. In most cases, the CBRs are in the same age range (25–35 years old) as the participants. In the cases where participants and CBRs are from the same community, they knew each other from similar social settings as well as through family networks. For the six CBRs who were First Nations, they shared a common First Nations identity with their participants, which also resulted in shared communication styles and intrinsic understanding of community life.

One issue that was discussed in this research was First Nations identity. It was considered as an important foundation for establishing relationships. The CBRs noted that their interactions with their research participants were guided by her traditional teachings: "I deal with them with respect and dignity. I use the seven grandfather teachings; honesty, humility, truth, wisdom, love, respect, and bravery." This theme continued through the second phase of the research. Having a cultural awareness was shown to be an important tool for successful community research because an established understanding of challenges in the community also provided a good foundation for trust building. As one respondent indicated: "I'm a First Nations person, I'm from the area. They know me, they know my background… I believe that helps with the trust."

The majority of the First Nations CBRs had similar childhood experiences and also had young children. CBRs were able to use this as a tool to develop a relationship with the participants. This approach is described by one CBR: "I share my story and use that as a way to build trust." Another respondent indicated the same idea: "We come from the same place, we have experienced the same issues, and we share the same culture, so it makes it easier." During the research, some of the CBRs were pregnant and gave birth. While this is consistent with the "insider" approach described by Ogawa (19), it is a unique type of researcher positioning described by Goldade's (20) experience as a new mother talking to other mothers about issues relating to infant health. The role of being a mother, especially a first time or new mother provided an important way for the CBRs to connect with participants. Several CBRs discuss how this shaped their connections with participants:

> I was pregnant at the time I was recruiting as well, so I felt I had more of a connection with the women. I thought I was more relatable with me being pregnant. And later on after I had my baby…I brought the baby with me. I had hoped that it would make a difference bringing the baby along.
>
> When I was pregnant, and I was speaking to women in the interviews, I was using myself as an example, saying that I didn't know a lot of the stuff until I started with the study. To show I guess that I…. I don't know how to explain it. To show I guess that it's ok that you didn't know it. It doesn't mean that you are ignorant or stupid and that it is actually more common not to know the stuff in the community.

In many communities, participants are initially reluctant to talk to CBRs. Even though participants have agreed to participate in the project, there are often other "gatekeepers" that the CBRs must go through in order to engage with the participant. One CBR shared an interesting story regarding connecting with the grandmother of a participant:

> There was one time I knocked on the door and there was a grandmother that answered the door. She didn't really want to let me in. She kind of opened the door and kind of looked at me and asked me who I was and what I was doing. After a while I introduced myself, she invited me in. Then we started talking about my sister, she knew my sister. I told her I was from (First Nation) and after that she was more welcoming. We talked about other stuff, and she asked about my sister and the visit was so awesome. After a while, when I told her who I am, where I'm from, and she asked me if I knew this person, we just had such a good visit!

The complexities of being a "native insider" as Laycock (17) describes is often nuanced and requires the researcher to develop ways to engage in multiple ways. CBRs often connected with participants by sharing personal information with them to "level the playing field." This is an important part of ensuring confidentiality (16). By giving up personal information to participants and making themselves vulnerable, it provides some assurances beyond the consent form of confidentiality. This was described by one CBR: "I share my story and use that as a way to build trust.

I also make sure I never tell anyone else what the participants tell me." The need for FNIM researchers to make themselves vulnerable by sharing personal stories about themselves is certainly one of the challenges that Indigenous researchers face (17), and it is important for those researchers to understand that this may be something they face in communities in which they are working.

One of the CBRs discussed sharing a childhood memory with her participants, which was a powerful way of connecting and shows the culturally specific context and understanding that is required for this project:

> One story I find myself sharing all the time is on the experience I had as a child receiving dental treatment that was really negative. I find the women also have this experience. They also had a lot of general anesthesia, and their first experience with the dentist was usually surgery and extracting teeth. So we didn't have good oral health experiences. Once we started talking about these experiences, they begin to realize how it has affected them now in terms of not going to the dentist's office.

Cross Cultural and Interpersonal Communication

Shared culture facilitates having shared experiences; this was less of a challenge for the First Nations CBRs than the non-First Nations CBRs for obvious reasons. Shared experiences such as motherhood and First Nations identity were not shared by the two non-First Nations CBRs, both of these CBRs were living in the large urban centers (Winnipeg and Toronto) and, instead, relied on other mechanisms to establish a relationship with their participants. Having an understanding of how different people communicate based on cultural differences and historical experiences and understanding how to adapt interpersonal communication approaches to develop rapport and trust was an issue that the non-First Nations CBRs undertook as a strategy.

The CBRs discussed the importance of making the participants feel comfortable, which in part is to ensure that they are not feeling judged. BTT participants can often feel judged about their skills as a parent, especially given the long history of child and family services intervening in many FNIM communities. CBRs must be cognizant of ensuring that participants are comfortable. One respondent described her approach as "learning to be open and relating to them. It's important to take the lab coat off. I like to treat it as a meeting of two girls chatting over coffee." Another respondent described this similarly:

> It's important to not be judgmental, and just to be willing to share your own experiences. I think you really have to be gentle and open with native women, Native people. Not to be authoritative, not to sound like you are preaching or like you have to teach them, but just that you are there for them.

To be effective community researchers, it is important to hire and/or train CBRs to consider the larger historical context of colonialism when engaging with participants. The need for culturally based communication styles is even more pronounced in remote communities where community members are less likely to engage with people who are not from their communities on a regular basis. One respondent from a remote community described the issues of communication:

> Around these areas, native people find non-native people or white, find them intimidating. It is almost kind of like authoritative figures. Not pushy, but like that same residential school mentally I guess. They have almost a fear, or they don't think of themselves on the same level maybe.

This type of sentiment is at the heart of why CBRs, even if they are non-First Nations or from the communities, requiring a deep sense of awareness of the larger context of the communities in which they are working. This was not a formal part of our vetting process in hiring CBRs; however, all of our CBRs had an understanding of this context, which was either inherent or learned through previous experience.

The literature supporting FNIM control of research highlights factors such as working in a participatory manner with community and shifts in control in which there is a lack of literature that describes the features that researchers should be considering when hiring local researchers who are the ones carrying out the majority of data collection. While there was no surprise that shared experiences, being able to identify with participants and build relationships was a key part of the success of the research, there are gaps in the literature to explain these features as a key determinant and outcome of successful research relationships in FNIM communities. Considering the large scope of the BTT project, it was considered worthwhile exploring this topic rather than "taking it for granted" that these factors were important.

CONCLUSION

The role of CBRs has become increasingly critical for the successful engagement with FNIM communities, who have long suffered from a history of poorly implemented research done by "outside" researchers. BTT has taken a community-based research approach, which is centered on the development of culturally appropriate research tools and dissemination, and engagement with participants in ways that are meaningful through the use of CBRs. The CBRs in BTT have recruited more than 500 participants over a period of approximately 14 months and the interventions are nearly completed. The effectiveness of the CBRs can be attributed to several factors. The importance of having a shared experience between the CBRs and the research participants paved the way for successful engagement. Shared identity and childhood experiences and relatability through motherhood were all important shared experiences that provided CBRs with a foundation to build trust and understanding. This foundation was further enhanced through cross cultural and interpersonal communication styles. BTT CBRs know how to effectively communicate with participants given their experiences with non-FNIM people, the larger history of colonial interactions, and the cultural modes of communication.

Given the long history of negative relations between researchers and FNIM communities, understanding the role of CBRs as being critical to engagement with community and participants cannot be understated. Whether CBRs are FNIM and from the community where research is taking place, or non-FNIM, all CBRs need to understand that research is not solely about the collection of data. Meaningful engagement requires CBRs to draw on their own foundation as people, using their own sensibilities, sensitivities, and experiences to develop and build relationships with participants. It is important not only for the research task at hand but also for the larger trajectory of research in FNIM communities and the ongoing development of healthy, collaborative relationships with researchers. Future research could consider whether health research in FNIM communities or other populations should solely rely on CBR from those populations specifically, or are there other more salient factors that need to be considered such as personal sensibilities and sensitivities and ability to communicate in different cultural settings.

ETHICS STATEMENT

Research ethics approval was obtained through the home institution of the interviewer and coinvestigator from the University of Winnipeg for this particular research. The participants were informed by email by the BTT Principal Investigator of the request to be interviewed and were informed that their participations were not mandatory and there would be no expectation to participate. Consent was obtained prior to the commencement of the interview. When the interviews were not face-to-face, the consent form was read out loud and participants indicated their agreement to participate. Written consent was obtained for the two interviews that were conducted face-to-face.

AUTHOR CONTRIBUTIONS

JC led this part of the BTT Study, initiated the analysis, and conducted the majority of the writing. MM, SP and HPL independently coded and participated in data analysis and interpretation of the results. HPL is the BTT Study PI in Canada and RS is a co-I on the BTT Study (Canada). They were all involved in revising the manuscript. LJ and JB are the BTT Study PIs in Australia and New Zealand, respectively.

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Busting the Baby Teeth Myth and Increasing Children's Consumption of Tap Water: Building Public Will for Children's Oral Health in Colorado

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Question: Can a multifaceted statewide communications campaign motivate behavior change in low-income Colorado families to limit children's fruit juice consumption and increase children's consumption of tap water to prevent tooth decay?

Purpose: Caries is the most common chronic disease of childhood, affecting 40% of kindergartners and 55% of third graders in Colorado. Frequent consumption of 100% fruit juice is linked to childhood caries. The purpose of this campaign, "Cavities Get Around," was to motivate families to limit children's fruit juice consumption and increase consumption of tap water to protect baby teeth from caries, while also building public will for children's oral health.

Methods: The campaign included targeted media, promotores/organizers, and family education. We focused on fruit juice because audience research showed many families view fruit juice as healthy, and it is also a common beverage among young children up to age of 6 years. We also focused on low-socioeconomic status families because data show higher childhood tooth decay rates in this population. To evaluate progress, we conducted identical pre- and post-surveys, each of 600 random low-income parents contacted by landline, mobile telephone, and Internet, allowing for comparative data.

Results: Significant progress was achieved compared to 2014 baseline results. Findings from a November 2015 statewide survey of parents included the following: (1) 22-point increase from 2014 in percentage of children regularly drinking tap water (from 41 to 63%). (2) 29-point decrease from 2014 in percentage of respondents who considered fruit juice consumption important to their child's health and nutritional needs (from 72 to 43%). (3) 19-point reduction in fruit juice consumption among young children (from 66% in 2014 to 47% in 2015). (4) 6-point reduction in percentage of parents considering baby teeth "less important" than adult teeth (from 21% in 2014 to 15% in 2015). The campaign also played a role in new state rules prohibiting childcare centers from serving sugar-sweetened beverages and capping 100% juice to twice per week.

Conclusion: The campaign development, strategies, and evaluation results are instructive for others working on health promotion, childhood nutrition, and education interventions.

Keywords: oral health, behavior change intervention, sugary drinks, fruit juice, early childhood caries

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INTRODUCTION

Dental caries, or tooth decay, is the most common chronic disease of childhood, with rates of disease at epidemic proportions, and yet it remains a "silent epidemic." (1) Early childhood caries is characterized by one or more decayed, missing, or filled teeth in children under the age of 6 years. The disease is transmissible and caused by multiple factors (2). Bacteria, *Streptococcus mutans*, and others produce strong acids when they metabolize sugars from foods and beverages. The acids erode tooth enamel, resulting in a cavity. Transmission of cavity-causing bacteria from a caregiver to child can occur. Caries has been termed a "diet-mediated disease" because sugars fuel the disease process (3). Consuming fruit juice[1] and sugar-containing beverages and snacks, especially between meals and before bed, elevates the risk of caries in children (4).

Untreated caries can be painful. For children, this can mean difficulty concentrating, speaking, and eating. A 2000 U.S. Surgeon General report, "Oral Health in America," found that more than 51 million school hours are lost every year due to dental-related illness (1). Untreated caries in young children can lead to premature loss of primary, or "baby," teeth, and disease in primary teeth can "spread" to erupting adult, or permanent, teeth. Children with oral pain earn lower grade point averages than children without oral pain (5). Sometimes, the treatment provided for extensive caries in children's teeth is visible stainless steel crowns, or "silver caps." Children with extensive tooth decay may require treatment under general anesthesia.

In Colorado, as in most other states, dental caries in young children is a serious public health concern with substantial human and financial costs. A 2012 report by the Colorado Department of Public Health and Environment (CDPHE) indicated that 39.7% of kindergarten children and 55.2% of third graders experienced caries, or tooth decay. Nearly one in seven children in both age groups (13.8% of kindergartners and 14.4% of third graders) experienced untreated tooth decay. In addition, the report revealed ethnic disparities. Among kindergarteners, 55.0% of Hispanic children and 38.0% of black children experienced caries compared to 31.9% of white children. Among children in third grade, 69.5% of Hispanic children and 56.4% of black children compared to 48.1% of white children experienced caries. Among children in kindergarten, untreated decay was higher among Hispanic children (18.5%) compared with black (16.8%) and white (11.4%) children (6). Income disparities also exist. The CDPHE report found that, in schools with at least 75% of students enrolled in free and reduced lunch programs, caries experience was as high as 53.1% in kindergartners and 73.4% in third graders (6).

Establishing good oral health in children can be a daunting and complex challenge, especially in low-income families (7). Access to care is one challenge. In 2015, according to the Colorado Health Access Survey, only 11.8% of children enrolled in Medicaid and the State Children's Health Insurance Program (SCHIP) had a dental checkup by age of 1 year, a recommendation for all children (8). The survey also indicated that, among Medicaid- and SCHIP-enrolled children up to 6 years of age, only one out of three had a dental exam in the previous 12 months (8). Thirty-seven percent of children aged 0–6 years from families earning less than 200% of the federal poverty level had not visited a dentist in the previous 12 months (8). Many dental providers are unwilling to see young children, especially children enrolled in public insurance programs. A 2015 report by the Colorado Health Institute reported that only 877 of the 2,654 practicing dentists in Colorado had provided services to at least one Medicaid enrollee in 2013–2014 (9).

Oral health behaviors and attitudes are another challenge. For example, many dental professionals working with pediatric patients report a common belief, or myth, among parents that baby teeth are of limited value since they "fall out anyway." This perception of baby teeth translates into less urgency to care for them. Poor nutrition (10), particularly overconsumption of sugars along with inadequate exposure to fluoride, is often another challenge. Fluoride helps prevent cavities. In Colorado, 74.91% of residents served by public water systems have access to optimally fluoridated water (11). Yet, among some immigrant populations, there is often skepticism about the safety of consuming water from public supplies (12), leading many children to consume fruit juices and other sugary drinks instead of tap water.

Putting these challenges together—insufficient access to oral health care, limited consumption of fluoridated tap water, high consumption of fruit juices and other sugar-containing beverages and snacks, and the belief that baby teeth have little value—it is not surprising that tooth decay rates are high among some Colorado families, especially those lower on the socioeconomic spectrum. Yet these challenges are not insurmountable. Recognizing that oral disease is largely preventable, Colorado's governor, in 2011, named oral health one of the state's "10 Winnable Battles," positioning the issue as a public concern (13).

Delta Dental of Colorado Foundation (DDCOF), guided by its mission to eradicate childhood tooth decay, launched a statewide initiative, using a "public will building" model, to establish children's oral health as a priority among community decision-makers and "influencers," policymakers, and families living at or below 200% of the Federal Poverty Level with children aged 0–6 years (14). The 0–6 years of age range was chosen because DDCOF's mission focuses on eradication of tooth decay in children.

Driving DDCOF's public will building initiative was the hypothesis that, if children's oral health were to become a priority for families, influencers, and policymakers, tooth decay could be prevented. Reducing children's access to and consumption of fruit juice, while increasing consumption of tap water, to protect baby teeth from decay became the focal point of this work from 2014 to present. This report details the development, strategies, and evaluation results associated with DDCOF's public will building program, specifically the "Cavities Get Around" campaign, as a potential model for others working on health promotion, childhood nutrition, and education interventions, and provides insights for additional child health initiatives.

MATERIALS AND METHODS

Overview of Public Will Building Development

The audience research that was conducted to inform development of the initiative was done within the context of a public-facing

[1] Defined as containing 100% fruit juice.

campaign with social marketing elements. The campaign was conducted over two large phases, the first from 2011 to 2013 and the second starting in 2014 (each will be described below). The results of the first phase informed the development and implementation of the second phase, which is ongoing.

(1) The primary objective of the Phase I work (2011–2013) was to better understand the problem of poor children's oral health, develop and launch a pilot public will building campaign focused on parents and their children brushing together, and assess effectiveness. Research informing this phase included in-home visits and focus groups with low-income families, interviews with experts and influencers, literature reviews, and an environmental scan. We used the findings from these activities to develop messaging that informed development of television and radio advertisements, a promotores de salud program (health promoters), and community partnerships. To evaluate the impact of this work, we conducted pre- and post-surveys of randomly selected low-income families.
(2) We adopted a different approach in Phase II (2014–present) based on findings from additional research involving low-income families and experts. Our Phase II primary objectives were to prevent tooth decay in children's baby teeth by increasing children's access to and consumption of tap water and decreasing their access to and consumption of fruit juice and other sugary drinks. We conducted focus groups, a statewide survey, and interviews and used the findings to develop a community-based campaign. The impact of the work was, and continues to be, measured from statewide survey results, which will be shared here.

TABLE 1 | Public will building for children's oral health in Colorado, Phase I pre-campaign research activities (2011–2012).

Activity	Type	Purpose
Background data scan	Interviews of children's oral health experts Conducted literature review	Identified segments of population most affected by tooth decay
Qualitative research with low-income families	Visits to homes Visits in clinics	Through visits with 49 families, assessed perspectives of populations most affected by early childhood caries
Qualitative research with low-income pregnant women and parents of young children	Focus groups (2)	Shared preliminary messages
Qualitative research with influencers	Focus groups (2)	Identified attitudes, knowledge, values, and motivators that might increase prioritization of children's oral health
Quantitative research	Random telephone survey	Established baselines for measuring progress over time
Brush with me campaign (launched April 2013)	Messaging campaign	Messages focused on behavior change, including better home care and parents and children brushing their teeth together. There was a secondary message of putting only water in sippy cups between meals and at bedtime
Post-assessment survey of brush with me campaign	Online survey	Assessed effectiveness of messaging campaign with low-income families in Denver metro area

Phase I (2011–2013)

Delta Dental of Colorado Foundation wished to use public will building to not only modify oral health behaviors but also to change social norms, systems, and policies at the institutional and public levels—all "from the ground up." This was the approach many advocates in the childhood obesity movement were using (15). Planning began in 2011, when DDCOF hired The Metropolitan Group, a Portland, Oregon firm with expertise in public will building. Pre-campaign research was conducted in Colorado in 2011 and 2012 (**Table 1**).

Following multiple research activities and analyses, the bilingual "Brush with Me" pilot campaign launched in April 2013. Focusing on behavior change within low-income populations in greater Denver, the pilot campaign led with the message, "Begin brushing your children's teeth, and your teeth, together every day." A secondary message of, "Between meals and at bedtime, put only water in your child's sippy cup or bottle," was limited only to the campaign website. The brushing message was conveyed through paid advertising and mass media, promotores de salud (health promoters within the Hispanic community), public events, and education programs with partners such as Children's Museum of Denver at Marsico Campus—all focusing on the Denver area.

The television advertisement ran on both English- and Spanish-speaking channels for much of the last 8 months of 2013. It showed a young girl with severe decay in an operating room and implored parents to brush their teeth with their children. This creative direction was tested in focus groups with low-income parents. Parents were told how inadequate child oral health could result in the need for emergency care requiring general anesthesia and how brushing their teeth with their child could help prevent cavities and create new healthy traditions. Avoiding the pain of untreated cavities resonated with them; many had experienced that pain firsthand and did not want it for their child. We shared that visits to emergency departments due to oral health problems in children were far more common than many realized. We showed how poor oral health could affect not just children but also their community. Participants told us this approach would get the attention of the communities they represented.

In late 2013, a post-assessment online survey of "Brush with Me," conducted by the campaign with 203 low-income families living in the Denver metro area, revealed no significant progress compared to a baseline telephone survey from February of the same year. This could have been due to the two surveys using different methodologies, underscoring a suboptimal evaluation framework. We decided to conduct additional research with low-income families and oral health experts to verify if the "Brush with Me" message was effective and, if not effective, identify a new direction. During this assessment, advertising of the "Brush with Me" message ceased.

Early Phase II (2014–2015)

The next phase of research began in early 2014, when a Denver, Colorado-based firm, HealthCare Research, Inc., was hired. The firm began the additional research to better understand the perspectives of the target population (low-income families with children ages 0–6 years) we wished to reach, gain new insights into the problem we were trying to address, and determine if "Brush with Me" provided an effective campaign direction. These research activities included qualitative and quantitative elements (**Table 2**).

In addition, we conducted behavior change modeling exercises to help us identify, as the research ensued, where low-income families might be in their attitudes, awareness, and actions related to children's oral health. The model we used, based on the Stages of Change from the Transtheoretical Model, showed the common steps in the behavior change process: (1) becoming aware of the issue, (2) forming a personal connection to the issue, or experiencing an "awakening," (3) contemplating making a change, (4) taking small steps toward change, and (5) committing to the change. We also developed a new logic model and evaluation framework (**Table 3**).

TABLE 2 | Public will building for children's oral health in Colorado, Phase II pre-campaign research activities (2014).

Activity	Type	Purpose
Qualitative research with oral health experts	Interviews of pediatric and general dentists, hygienists, and oral health professionals	To gain better understanding of the challenges providers experienced and identify solutions they believed could make the biggest difference in improved oral health
Exploratory qualitative research with low-income parents	Parent focus groups, English and Spanish (4)	To explore attitudes and behaviors toward unnecessary pain and suffering from tooth decay, the possibility of being cavity-free for life, the toll of painful cavities on school performance and attendance, the importance of aesthetics, the lifelong impact of poor oral health, and creating positive oral health behaviors at a young age
Baby teeth matter message platform and concept testing	Campaign development; creative concept testing	To synthesize the findings from the expert interviews and exploratory parent focus groups, and then outline desired message tone, why baby teeth matter, how cavities form, what parents/caregivers can do, and the benefits of desired behaviors
Creative concept testing qualitative research with low-income parents	Parent focus groups, English and Spanish (4)	To test potential creative directions for a new campaign. Results from the testing were obtained through a four-step process and informed the direction that was chosen
Pre-campaign statewide survey of low-income families (2014)	Telephone and online survey of 603 families	To assess reactions to message content derived from the expert interviews and exploratory focus groups, and establish a baseline of results to measure future progress related to the perceived importance of baby teeth and attitudes and behaviors related to children's fruit juice and water consumption. Coding techniques were used to synthesize responses to the open-ended questions

Strongest Campaign Concept

From analyses of focus group and quantitative survey findings, we determined that the most effective campaign concept was "Cavities Get Around." The concept showed how "cavities can spread from baby teeth to adult teeth" and implored, "Don't let that happen to your child's mouth." Focusing on the importance of baby teeth, limiting fruit juice consumption, and serving more water, "Cavities Get Around" was flexible enough to allow for a behavior change effort as well as the larger goals of building public will for children's oral health. "Cavities Get Around" was especially appealing since the idea of cavities spreading from baby teeth to adult teeth was new to and memorable with the population we sought to reach.

Phase II Campaign Goals

The "Cavities Get Around" campaign launched in August 2014. To map out how the campaign would evolve over time, we created a logic model describing short-term, intermediate, and long-term outcomes of the work (**Table 3**).

- Short-term: through targeted advertising, social media, promotores de salud, educational programs, text messaging, and other means, raise awareness of the importance of baby teeth,

TABLE 3 | Delta Dental of Colorado Foundation public will building logic model (developed in 2014).

Inputs: What resources are needed?	Activities: What needs to be done to create early momentum?	Outputs: How do we know we are completing important work?
• Funding • Reliable quantitative and qualitative data • Evaluation framework to gauge success • Partners and synergies	• Targeted advertising • Public relations activities • Family engagement and promotores • Community organizing • Policy advocacy • Network building through partnerships	• Number of impressions • Number of contacts • Number of participants • Connections among decision-makers and leaders
Short-term outcomes: What do we need to achieve in years 1–3?	**Intermediate outcomes: What is the path to success?**	**Long-term outcomes: What are we trying to accomplish?**
Increased awareness among low-income families that: • Baby teeth matter because cavities can spread from baby teeth to adult teeth • The sugar content in fruit juice is harmful to baby teeth, and so juice should be limited to mealtimes • Tap water is healthy and is what children should drink between meals and at bedtime	Children's oral health is prioritized such that: • Social norms change (priorities and expectations) • Commitment happens at the family and community levels • Policies change at the institutional and public levels to support healthy baby teeth	• Eradication of cavities among children in Colorado

the oral health impacts of unlimited fruit juice consumption, and the benefits of water, especially fluoridated tap water, on children's oral health. Also, achieve behavior change, specifically more families serving children only tap water between meals and at bedtime.
- Intermediate: create new positive social norms for children's oral health through local community engagement, using trusted ambassadors such as promotores de salud, organizers, and influencers. If community residents, committed to the "movement," joined together, could they create new norms around children's oral health such that cavity-free children were the expectation? By the same token, could communities change local practices to create healthier environments, with water and not fruit juice and other sugary drinks as the default beverage for children? Further upstream, could momentum in communities, bolstered by public relations activities, then spark public policy interventions, such as measures to curb consumption of sugary drinks, expand access to water, improve access to oral health care, etc.?
- Long-term: if we could generate momentum in communities, we could feasibly create a Colorado where eradication of cavities may become realistic.

Advertisements

Advertising was among the multiple components of the campaign. Reflecting our research learnings, a new advertisement, released in English and Spanish, had a light tone to it, while still delivering an important, actionable message. Instead of adding to the stress and "noise" already encountered by the families we wished to reach, we chose to provide quality health information in a fun and approachable manner. This was embodied in our "sugar troll" advertisement, the first commercial released under the new "Cavities Get Around" campaign.[2]

The 30-s advertisement depicted a mother and her young child sitting at a kitchen table in a modest home. The mother is about to pour her child a glass of fruit juice when a "sugar troll" appears. The Muppet-like creature, meant to represent poor oral health, has decayed teeth and is visibly happy that the mother is about to serve the fruit juice to her child. In the midst of his excitement as the mother is reaching for the juice, he loses a tooth, which falls to the floor. Suddenly, the mother has second thoughts and puts the juice back down on the table and reaches for a pitcher of tap water. Meanwhile, the sugar troll is visibly upset by her healthier choice and then retreats. The child drinks the water. The voice-over in the advertisement has meanwhile been talking in simple terms—and tracking with the scene—about the importance of baby teeth, how cavities can spread, how the sugar in juice can be harmful to children's oral health, and why water is beneficial. A "Sugar Troll" radio advertisement (English and Spanish) was also developed.

In 2015, a second, complementary set of visual advertisements was developed. In these English and Spanish advertisements, various junk foods, such as donuts and churros, were blended and then the contents placed next to a fruit juice container to show equal amounts of sugar in both items.

Advertising included television (English and Spanish outlets), traditional radio, digital/online (including online radio), billboards, and social media. The advertising and creative agency, Amélie Company in Denver, Colorado, targeted all paid media at low-income mothers ages 18–34 across Colorado.

Partner Assistance

In addition to advertising, various outreach programs were implemented through partners. Curricula for training promotores de salud were developed for two partners (see below). All partners agreed to be tightly coordinated in delivering the core messages related to the importance of baby teeth, limiting fruit juice to mealtimes, and serving only water, particularly tap water, between meals and at bedtime. To maximize impact, each partner was provided with various bilingual giveaways for families, including brochures about why baby teeth matter and why water, not fruit juice, is the healthiest beverage to serve to young children; sippy cups that said "only water, please" in English and Spanish; and posters, magnets, and other materials. Partners included:

- Children's Museum of Denver at Marsico Campus, an influential non-profit organization, launched three "Healthy Smiles" oral health programs. The programs included a weekly story time, the no-cost "Molar Expedition" program for Title I schoolchildren, and a summer in-museum offering for families that has since been replaced with a live "Sugar Scaler" demonstration for families in the museum's teaching kitchen.
- A promotores de salud (Hispanic, underserved and rural community health educators) and, eventually, coalition building program launched in Pueblo through a partnership with Southeastern Colorado Area Health Education Center. A curriculum for training the promotores was developed in 2014 and fully implemented in 2015. The curriculum aligned with "Cavities Get Around" messaging.
- A grassroots community organizing initiative through Westwood Unidos launched in Southwest Denver, an area disproportionately affected by childhood obesity and heavily populated by Latino families (16). A "Cavities Get Around" curriculum for training the organizers, similar to the Southeastern Colorado Area Health Education Center curriculum, was developed in 2015.
- Bright By Three (then known as Bright Beginnings) implemented "Cavities Get Around"-specific oral health messaging in its home visitation programs for families with children infant to 3 years of age. Bright By Three also added oral health messages to a statewide text messaging campaign it was launching.
- Qualistar Colorado began training child care providers in Cavity Free Kids, an existing oral health education curriculum for children with messages aligning with the "Cavities Get Around" campaign. Cavity Free Kids teaches five basics of children's oral health: the importance of baby teeth; drinking water for thirst; eating tooth-healthy foods; brushing, flossing and swishing; and going to a dental provider.
- DDCOF's Colorado Medical-Dental Integration (CO MDI) Project, a program integrating registered dental hygienists

[2]The "Brush with Me" campaign had been retired and entirely replaced with "Cavities Get Around." See www.CavitiesGetAround.com (English) and www.LasCariesSePropagan.com (Spanish).

in medical office settings to improve access to care for low-income populations. "Cavities Get Around" materials, such as bilingual brochures, magnets, and posters, were distributed to CO MDI hygienists and clinics.

Media Outreach

We increased efforts to engage influential media outlets to start covering the issue of children's oral health. The goal of these earned-media efforts was to drive awareness among influencers and policymakers of the epidemic of poor child oral health and start "planting seeds" for the public will building aspects of the work. Notable examples of key media exposure included a story on Colorado Public Radio (CPR) about the "silent epidemic" of tooth decay in children and another story on CPR about efforts to engage Latino communities on drinking tap water. The second story was later picked up by National Public Radio and ultimately covered in a slightly different way by *The New York Times*. Opinion editorials about policy issues, such as new requirements announced by the Food and Drug Administration for the nutrition facts label and the Colorado healthy beverage policy for schools, also created opportunities to reach influencers. In addition, we leveraged paid media partnerships to create quality editorial coverage, such as the campaign director appearing on popular morning new programs to blend donuts to show how much sugar is in fruit juice. Social media helped expand the reach of this exposure.

Policy

In addition to the social renorming and behavior change work through the "Cavities Get Around" campaign, we joined efforts to support policy opportunities as they surfaced. This included developing alliances with organizations working to reduce and prevent childhood obesity specifically through efforts to curb children's consumption of and access to sugary drinks. For example, in 2015, the campaign joined a large coalition effort to support, and advise on, the nutrition components of a set of draft rules the State Board of Human Services was considering for all licensed childcare centers in Colorado. In addition, DDCOF funded a non-profit organization, Healthier Colorado, to support efforts to educate the public about community water fluoridation and its benefits to oral health.

Phase II Mid-Campaign Statewide Survey of Low-Income Families (2015)

In November 2015, nearly 18 months after the "Cavities Get Around" campaign launched, we conducted a second statewide survey to evaluate progress. Using similar methods as used in the 2014 baseline survey, we surveyed 600 randomly selected low-income parents from across Colorado, who were contacted by landline, by mobile telephone, and online, and were asked many of the same questions, especially those related to beverage consumption, the importance of baby teeth, and attitudes and behaviors related to brushing and visiting a dental provider. The same inclusion criteria used for the 2014 survey were applied to the 2015 survey: (1) must reside in the state of Colorado; (2) must have a child living at home between 6 months of age (provided they have their first baby teeth) and 6 years of age; (3) must be the person in the household who oversees the health care needs of the child; and (4) must have an annual household income below 200% of the 2015 federal poverty guidelines.

Analytic Approach for 2014 and 2015 Statewide Surveys

The completed interviews for the 2014 and 2015 statewide surveys yielded a maximum margin of sampling error of ±4 percentage points at the 95% level of confidence. Once the data for both surveys were weighted by geography to reflect U.S. Census estimates and checked for accuracy and integrity, the results were tabulated and analyzed using the same approach.

Statistical significance testing was employed when looking at differences between various participant segments/groupings within the data as well as between the 2014 and 2015 statewide assessments included in the results. Only differences that could be cited as being of statistical significance at the 95% level of confidence were reported or if that level of confidence was not achieved.

When comparing differences between various demographic or geographic segments within a single cross-sectional dataset, *t*-tests of means or proportions were used, comparing the percentage (or mean) for that group to everyone else (meaning the group of interest was excluded from the comparison). Testing was performed at the 95% level of confidence using IBM SPSS Statistics for Windows, Version 19.0. Two-tailed hypothesis testing was employed, and variances were tested for homogeneity using Levene's Test of Equality of Variances.

When testing for differences *between* the two cross-sectional statewide surveys (2014 and 2015), independent *t*-tests of proportions and means were once again used for identifying differences which were of statistical significance at the 95% level of confidence. Two-tailed hypothesis testing was employed (H_o: $u_{pre} = u_{post}$), providing a more conservative test result than if the null hypothesis were presented with the assumption that the campaign's message had created the desired impact on the variables of interest (i.e., H_o: $u_{pre} < u_{post}$).

In comparing the results of the 2014 and 2015 statewide surveys, of greatest interest to us was if there had been progress related to the key goals of the campaign:

- Did more parents and caregivers understand that the sugar in fruit juice was harmful to children's oral health and, as such, reduce how much they were serving their child(ren)?
- Did more parents and caregivers understand the oral health benefits of tap water for children and, as such, increase how much they were serving to their child(ren)?
- Did more parents and caregivers understand the importance of baby teeth, i.e., baby teeth are just as important as adult teeth?

Ethics Approval Statement

The 49 in-home and in-clinic interviews with families in early Phase I were approved by the Center for Research Strategies in Denver, CO, USA. We completed an application for this work and met the requirements for the center's ethical evaluation and approval of the study. Phase II did not require Institutional Review Board approval as it was a social campaign. The data presented are from a program evaluation.

RESULTS

Expert Interviews

The expert interviews were intended to provide a solid scientific basis for the ensuing research with low-income families. A "storyline" emerged from the key themes from the interviews (**Table 4**). The storyline "connected the dots" between behaviors and long-term outcomes and brought the realization that any effort to prevent caries in young children had to begin by establishing an understanding of why baby teeth matter. This "value proposition" had to be the central motivation for families and the community to care about preventing early childhood caries to the extent that they would change behaviors, norms, and environments.

Exploratory Parent Focus Groups

The exploratory focus groups revealed a common perception of baby teeth as disposable and transitory. We heard that almost every parent *said* their child's baby teeth were important, but they did not know why, and thus there was little motivation to care for them, especially when juxtaposed against all of the other priorities of parenting. While nearly all parents told us their children's teeth were brushed every day, they were willing to talk about how often they "skipped" brushing, especially if their child had fallen asleep before going to bed or was feeling unwell. Many parents also told us they regularly sent their children to bed with milk or some type of sugary drink to help them sleep. A few commented in the focus groups that they felt overwhelmed by the large amount of milk and fruit juice received though the Women, Infants, and Children's Program. The information we shared about the importance of baby teeth—for example, cavities could spread from baby teeth to adult teeth and sugar fueled cavity-causing bacteria—was new to almost everyone. This information in turn led several participants to tell us in the focus groups that they desired a change in their behaviors. Many left the sessions saying they would change their oral health practices at home because of what they had just learned.

Connecting the findings from our exploratory focus groups to our previous behavior change modeling exercises, we realized that our public will building work had to start with basic awareness building related to why baby teeth matter and simple ways to protect them from decay.

TABLE 4 | Key themes from expert interviews (conducted in 2014).

Key themes—what the experts told us	Layman's storyline—what it meant to families with young children
Among many parents and caregivers, there is a lack of understanding of the importance of baby teeth. The thinking is that baby teeth are expendable since children will lose them anyway	Cavities can spread from baby teeth to adult teeth, setting a child up for a lifetime of oral health challenges
Sugary beverages, especially fruit juice served in sippy cups, contribute to poor oral health in children just as much as inadequate teeth brushing	Sugar serves as fuel for bacteria that live in children's mouths. These bacteria, when fueled by sugar, create acid that eats away at the thin enamel of children's baby teeth, leading to cavities
Families from Mexico often do not drink tap water because of water safety issues in their native country. This practice in turn reduces exposure to fluoride and increases the consumption of sugary beverages	Tap water is safe and healthy, and the fluoride in tap water protects teeth against decay

Statewide Surveys

The sociodemographic characteristics of the 2014 and 2015 statewide survey cohorts were similar (**Table 5**). The majority of families lived in the Denver Metro area or Front Range. Slightly less than half of those surveyed were Hispanic.

2014 Survey Results

The findings from the 2014 survey of low-income households led to the focus on the importance of protecting baby teeth by serving only water (particularly tap water), and not fruit juice, to children between meals and at bedtime (**Table 6**).

TABLE 5 | Comparison of methodologies between 2014 and 2015 statewide surveys in Colorado.

	April 2014 sample size	November 2015 sample size
Geographic region		
Denver Metro	273	279
Front Range	120	125
Southern	90	81
Eastern	48	47
Mountains/West	72	68
Totals	603	600
Hispanic/Spanish speaking		
Of Hispanic origin	44%	42%
Spanish speaking	26%	25%

TABLE 6 | Results from 2014 statewide survey[a] of 603 low-income households.

Key findings

- Although 87% of surveyed parents reported that their children's teeth were brushed, only 1% of those surveyed reported they brushed their child's teeth for 2 min, twice a day, every day.
- Thirteen percent reported their child was too young to brush, which included 34% of those under 2 years of age, 15% of children 2–3 years of age, and 5% of children 4–5 years of age.
- Thirty-five percent reported they had taken (or planned to take) their child to the dentist by the age of 1 year.
- Eight-seven percent of parents said their child drank fruit juice at least several times a week, and 55% said the beverage their child was most likely to be walking around with during the day was fruit juice.
- Seventy-two percent of parents said they believed fruit juice to be important to the health and nutrition of their child.

Winning messages (after coding responses)

- Importance of baby teeth: it is important to take care of your child's baby teeth because cavities in their baby teeth can easily spread to their adult teeth.
- How cavities form: sugar is like fuel for cavities. Sugar is found not only in sweets like candy but also in fruit juice, soda, and chocolate milk.
- What parents can do: parents should limit their children's consumption of fruit juice and other sugary drinks to mealtimes, and serve only tap water between meals and especially at bedtime.
- Benefits of child oral care: not only will all of this help prevent cavities but also parents will give their child a beautiful smile; healthy, white teeth; and clean, fresh breath.

[a]*Results include telephone and online survey.*

2015 Survey Results

Thirty-nine percent of all 2015 survey respondents reported they had seen the "Cavities Get Around" campaign advertising; 46% of participants living in Denver reported they had seen the advertising. Comparisons of the November 2015 statewide survey (all respondents) to the 2014 baseline results (**Table 7**) include the following:

- Increase in the percentage of children aged 0–6 years regularly drinking tap water: 41% (2014), 63% (2015), $p < 0.01$.
- Increase in reported tap water consumption in children aged 2–3 years: 39% (2014), 64% (2015), $p < 0.01$ and children aged 4–6 years: 45% (2014), 69% (2015), $p < 0.01$.
- Increase in reported tap water consumption in Hispanic children: 34% (2014), 60% (2015), $p < 0.01$.
- Decrease in reported perception that fruit juice is important to their child's health and nutritional needs: 72% (2014), 43% (2015), $p < 0.01$.
- Decrease in reported daily fruit juice consumption among young children aged 0–6 years: 66% (2014), 47% (2015), $p < 0.01$. Broken down further, the reductions in fruit juice consumption were as follows:
  - Children aged 6 months to 1 year: 55% (2014), 32% (2015), $p < 0.01$.
  - Children aged 2–3 years: 69% (2014), 48% (2015), $p < 0.01$.
  - Children aged 4–6 years: 69% (2014), 49% (2015), $p < 0.01$
  - All Hispanic children (ages 0–6 years): 68% (2014), 46% (2015), $p < 0.01$.
- Reduction in the percentage of parents who considered baby teeth "less important": 21% (2014), 15% (2015), $p < 0.01$.

The results also indicated the following:

- Decrease in reported daily consumption of plain (unflavored) milk among children aged 0–6 years: 90% (2014), 82% (2015), $p < 0.01$.
- Increase in reported daily consumption of flavored milks among children aged 0–6 years: 13% (2014), 23% (2015), $p < 0.01$. Additional breakdowns for flavored milk consumption included:
  - Reported increase among children aged 2–3 years: 13% (2014), 29% (2015), $p < 0.01$.
  - Reported increase among children aged 0–6 years living in the Denver metro area: 11% (2014), 23% (2015), $p < 0.01$.
  - Reported increase among children aged 0–6 years living in the Front Range (excluding Denver metro area): 13% (2014), 29% (2015), $p < 0.01$.
  - Reported increase among Hispanic children aged 0–6 years: 15% (2014), 29% (2015), $p < 0.01$.

TABLE 7 | Comparison of results from first and second statewide surveys of low-income families conducted in April 2014 and November 2015.

	April 2014 (%), $N = 603$	November 2015 (%), $N = 600$	p-Value*
Importance of baby teeth compared to adult teeth			
Much more important	3	7	<0.01
Somewhat more important	4	7	0.02
Equally important	71	70	n/s
Somewhat less important	16	12	0.05
Much less important	5	3	0.04
Which of the following types of beverages does your child drink? How often do they drink… (% "daily")?			
Tap water	41	63	<0.01
Bottled water	57	56	n/s
Fruit juice	66	47	<0.01
Flavored milk	13	23	<0.01
White milk	90	82	<0.01
Soda	2	3	n/s
How important is it for your child to drink (item) for their health and nutrition? (% "extremely" and "very important")			
White milk	96	88	<0.01
Tap water	43	57	<0.01
Bottled water	65	60	n/s
Fruit juice	72	43	<0.01
Flavored milk	13	18	0.01
Sports drinks	4	7	0.02
Soda	3	4	n/s
When your child is walking around during the day with something to drink, what are they usually drinking?			
Tap water	29	41	<0.01
White milk	40	39	n/s
Bottled water	43	37	0.03
Fruit juice	55	31	<0.01
Flavored milk	7	9	n/s
Sports drinks	2	4	0.04
Soda	1	2	n/s

n/s, not statistically significant.

χ^2-test of association not suitable for tables that include multiple response variables. Analysis of variance was not used since the data are ordinal rather than interval.

**$p < 0.05$ is significant.*

$\chi^2(4, n = 1,203) = 21.2754$, $p < 0.001$.

ANOVA calculation was not used because the data are ordinal.

Policy

Delta Dental of Colorado Foundation provided specific comments and requests in the draft rules ultimately approved in late 2015 by the Colorado State Board of Human Services for all licensed childcare centers in Colorado. The rules included tighter nutrition standards, specifically prohibiting centers from serving sugar-sweetened beverages to children (the rules did not prohibit parents/caregivers from sending their child to a center with a sugar-sweetened beverage). DDCOF encouraged the state board to consider including flavored milks in the list of prohibited sugar-sweetened beverages, and this change was made (flavored milks were not included in the draft released by the state board for public comment). In addition, the rules limited 100% fruit juice to twice per week.

DISCUSSION

Delta Dental of Colorado Foundation implemented a large, multifaceted public will building program, known as "Cavities Get Around," between 2014 and 2015. The campaign's development was informed by the low-income families it was designed to reach in these first 2 years. The program included a range of community interventions, from targeted advertising and public relations to well-trained promotores de salud, community organizers, text messaging, and various health educators who disseminated the key messages to families and communities. The program culminated in the sharing of two key messages: importance and safety of drinking tap water and the impact of drinking fruit juice on children's baby

teeth and oral health. In random surveys of two unique populations living in Colorado in 2014 and 2015, various oral health reported characteristics changed among parents/caregivers, including improved perception of the importance of children drinking tap water, reported increase in children's consumption of tap water, reported decrease in the perception of fruit juice consumption as healthy for children, and reported decrease in children's consumption of fruit juice. While we cannot account for the influence of outside secular trends on participants' reported characteristics, we were encouraged to see an improvement in the perceptions and behaviors targeted with the program. The impact of broad public health campaigns is hard to measure but our results suggest that our public will building program may have had an important impact on Coloradan families. We also were encouraged that 39% of participants statewide and 46% of participants in the Denver metro area who were surveyed in 2015 could recognize our advertising, indicating its penetration in the target communities and that the campaign messages were memorable. The campaign also made inroads with public policy by working within a large coalition of health-focused organizations to successfully advocate for healthier nutrition standards for licensed childcare centers in Colorado.

Other Colorado efforts have primarily targeted reduction of sugar-sweetened beverages, such as soda. Our work was unique from other Colorado efforts in that we focused on raising awareness of the harmful effects of sugar in fruit juice on children's oral health and on promoting the benefits of tap water. We are not aware of any other efforts with a similar focus on fruit juice and tap water.

Rather disturbing were the statistically significant reported increases (see **Tables 7** and **8**) in flavored milk consumption among children in the surveyed population, especially 2- to-3-year -old (+16%), children living in the Denver metro area (+12%), and Hispanic children (+14%). We are left to speculate on what may have contributed to reported large increases in children's flavored milk consumption in the Denver metro area, including the potential that some families reached by the "Cavities Get Around" campaign may have replaced serving their child fruit juice with flavored milks.

TABLE 8 | Comparison of results from first and second statewide surveys, assessing family attitudes and behaviors related to drink consumption among Hispanic children.

	April 2014 (%), $N = 264$	November 2015 (%), $N = 246$	p-Value*
Which of the following types of beverages does your child drink? How often do they drink… (% "daily")?			
Tap water	34	60	<0.01
Bottled water	60	67	n/s
Fruit juice	68	46	<0.01
Flavored milk	15	29	<0.01
White milk	93	62	<0.01
Sports drinks	3	8	0.01
Soda	1	3	n/s
How important is it for your child to drink (item) for their health and nutrition? (% "extremely" and "very important")			
White milk	95	89	0.01
Tap water	41	52	0.01
Bottled water	68	64	n/s
Fruit juice	73	41	<0.01
Flavored milk	18	25	0.05
Sports drinks	4	10	0.01
Soda	4	6	n/s
When your child is walking around during the day with something to drink, what are they usually drinking?			
Tap water	22	34	<0.01
White milk	33	41	n/s
Bottled water	46	51	n/s
Fruit juice	56	27	<0.01
Flavored milk	8	7	n/s
Sports drinks	0	5	<0.01
Soda	1	3	n/s

n/s, not statistically significant.
**$p < 0.05$ is significant.*
$\chi^2(4, n = 1,203) = 21.2754$, $p < 0.001$.
ANOVA calculation was not used because the data are ordinal.

Limitations

This study has limitations. Though sampling methods used for the first and second household surveys were similar, the respondents were different, making it impossible to know if attitudes and behaviors changed in specific families or individuals. However, random sampling was an effective means for measuring impact of the paid media aspects of the campaign between the baseline and follow-up surveys. In addition, responses given for the household surveys were self-reported and were unverified by observation. Also, we cannot account for the impact of societal trends on the oral health perceptions and behaviors targeted with this work.

CONCLUSION

Lessons Learned

In Phase I, we chose the obvious path for a children's oral health campaign—tooth brushing—in implementing the public will building initiative in Colorado. Perhaps this was because tooth brushing seemed the highest-impact way to get parents actively involved in preventing caries in their children. This was what parents told us in early focus groups, as well. Overlooked in our Phase I exploratory work was assessing underlying attitudes about baby teeth and the need for a central value proposition: in our case, the importance of baby teeth and the spread of cavities from baby teeth to adult teeth. If the importance of baby teeth was not firmly established, any attempt to change behaviors, social norms, and environments—and build public will for children's oral health—might fall short. Establishing the importance of baby teeth and a simple way to do so (serve children only water between meals and at bedtime) became the central aim of the Phase II "Cavities Get Around" campaign and it led to strong results. Others involved in children's oral health campaigns and programs may want to consider building their messaging around the central value proposition of why baby teeth matter.

In addition, as we found in our Phase II research, the greatest knowledge gap was not the need to brush children's teeth. It was why baby teeth mattered and the adverse impact of fruit juice, consumed between meals and at bedtime, on baby teeth and the oral health benefits of tap water. These knowledge gaps needed to be addressed not just in homes but also in childcare centers, schools, and similar environments influencing children's oral health. Just focusing on promoting healthy behaviors in the home would have been limiting.

The Flint, Michigan water tragedy also served as a lesson learned. In that case, children in Flint, an economically depressed area, were exposed to lead in the public water system. The Flint crisis publicly surfaced shortly after the 2015 survey concluded. In the wake of Flint, we gathered as much information from local water utilities as possible and used these learnings to modify our messaging to urge families to drink water from whatever source they were most comfortable, though we did continue to emphasize the benefits and safety of fluoridated tap water. Had we not made this change across all facets of the campaign, we believe our overall message might have lost credibility among those we wished to reach.

Campaign Today

The results from 2014 to 2015 exceeded our expectations. The campaign today remains focused on the same messages related to the importance of baby teeth and children drinking only water between meals and at bedtime but has evolved. For example, in parent workshops at schools, the oral health impacts of unlimited fruit juice consumption continue to be an emphasis, but within a larger conversation about the impacts of *all* sugary drinks on children. In 2016, the campaign replaced the "sugar troll" commercials with a new set of advertisements that more clearly communicated the desired behaviors and expanded the issue to a community frame. Reflecting feedback from another set of focus groups, the commercial used three scenes to reveal how much sugar is in various containers of fruit juice. The scenes—two at home and one at a youth soccer game—show containers that look like fruit juice but are actually full of sugar. The advertisement ends with a young girl reaching for a glass of tap water, with the voice-over saying, "healthy teeth and bodies need water."

In addition, the campaign is making concerted efforts to affect institutional policy change to create new positive norms and expectations for children's oral health. In Southwest Denver, partner Westwood Unidos has focused on family education, parent advocacy, school wellness, and training and mentoring of resident leaders and other influencers to spearhead policy change in schools and other community settings. Evidence may suggest that children in schools where sugary drinks are restricted have fewer cavities (17). Public relations tactics are then used to disseminate these institutional policy changes, such that they may be emulated in other parts of the community or state. In 2016, news coverage of our work included a feature in *The New York Times* (18). In 2017, we are developing an activation kit for Colorado communities to use to expand access to drinking water for children in schools and other public spaces.

Meanwhile, since 2015, the *Healthy Beverage Partnership* (HBP), representing Denver metro county health departments, has launched efforts to reduce sugary drink consumption in the region, specifically related to type 2 diabetes, obesity, cardiovascular disease, and tooth decay. HBP uses paid media for its "Hidden Sugar" campaign to raise awareness; works with community organizations to adopt healthier vending, meeting, and concession policies; and supports community coalitions to help promote model policies. The "Cavities Get Around" campaign and HBP share information to allow for advertising efforts to complement each other rather than duplicate efforts. In addition, Delta Dental of Kansas has brought the advertising components of the "Cavities Get Around" campaign to various markets in its state.

Future

Delta Dental of Colorado Foundation is committed to supporting efforts to raise awareness of the importance of children's oral health, to the extent that children's oral health is valued and prioritized in homes, childcare centers, schools, social service programs, and communities. The campaign may expand its grassroots outreach in the immediate years ahead. If the campaign focused only on behavior change and were not also working with residents to change community social norms, expectations, and environments, we speculate that it is unlikely progress could be sustained. "Old habits die hard," except in cases where these habits have become socially unacceptable. We are working toward a future with better oral health and overall health, when children drink mainly water and have healthy choices at and between mealtimes.

A third statewide survey will be conducted in late 2017, and the data from it will be measured against 2014 and 2015 results to assess progress and identify new and ongoing opportunities for focus. DDCOF will also continually monitor statewide data on rates of caries in children to gauge impact.

AUTHOR CONTRIBUTIONS

WH is the lead author and is campaign director for this program. WB is a public health dentist from the University of Colorado and an expert adviser to the campaign. PB is a pediatrician from the University of Colorado and Denver Health and an expert adviser to the campaign. KW owns the firm (HealthCare Research, Inc./Market Perceptions, Inc.) that has provided research and evaluation services to the campaign. He is a trained statistician. JH works at HealthCare Research, Inc., where he has facilitated all focus groups and helped synthesize findings.

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The reviewer, TT, declared a shared affiliation, though no other collaboration, with two of the authors, WB and PB, to the handling editor, who ensured that the process nevertheless met the standards of a fair and objective review.

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