UNDERSTANDING MULTILEVEL FACTORS IN PREVENTION OF CAVITIES AMONG JAPANESE CHILDREN

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ABSTRACT

The objective of this dissertation is to understand multilevel factors in prevention of cavities among Japanese children. Oral health is important to general health and quality of life, and cavities cause irreversible negative damage over the life course. This dissertation consists of three studies.

The first study is a systematic review to examine school-based interventions to prevent cavities for elementary school age children in Japan. Of the 13 included studies, 12 tested fluoride mouth-rinsing (FMR) programs. FMR programs appear to be very effective in preventing childhood cavities in Japan, which does not have systemic water fluoridation.

The second study was used quantitative methods to examine factors to explain disparities in cavities among 12-year-old children across Japan's 47 prefectures. Data by prefecture were culled from public databases and analyzed using SPSS. Three factors--average income per person in the prefecture, percentage of schools in the prefecture with school-based FMR interventions, and average numbers of convenience stores per 100,000 persons—explained almost 50% of national variance in cavities of 12-year-old children in Japan.

The third study was used qualitative methods to examine barriers and facilitating factors for Japanese parents living in Hawai‘i to prevent cavities for their children. Uninsured status, slow adaptation to the U.S. oral health system by Japanese mothers, and Japanese hesitancy to ask questions were found to be the main barriers. Insured status, high cost for insurance and treatment, and the U.S. check-up appointment system were found to be the main facilitating factors.

In conclusion, this dissertation found strong evidence that FMR should be introduced at all schools in Japan as a culturally competent approach to reducing cavities in children. Findings also suggest that municipalities in Hawai‘i need to be aware that short-term residents from Japan have limited knowledge of the U.S. oral health care system. They also have passive attitudes about prevention of cavities in their children due to Japanese policies that provide free annual check-up at schools and low or free treatment. Therefore, policy makers in Japan also need to support programs that teach parents to take more responsibility for preventing cavities in their children.

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LIST OF ABBREVIATIONS

- DMFT = Decayed (untreated), Missing, and Filled (treated) Teeth (the number is used as a benchmark of cavities among children)
- FMR = Fluoride Mouth Rinsing (one of cavity prevention methods)

CHAPTER 1: INTRODUCTION

Oral health is essential to general health and quality of life (World Health Organization, 2012). Cavities are associated with poor academic performance (Blumenshine et al., 2008; Jackson et al., 2011), physical disability, dementia (Yamamoto et al., 2012), and low quality of life (Petersen, 2003). Also, periodontal diseases are associated with HIV/AIDS infection (Petersen et al., 2005), diabetes, cardiac diseases, brain infarct, and immature birth (Preventing Cavities, Gum Disease, Tooth Loss, and Oral Cancers At A Glance, 2011). Oral infections can even cause death (Petersen, 2003).

Since poor oral health in childhood can cause irreversible negative damage over the life course, the prevention of cavities is the key to promote better oral health for all generations. Prevention during elementary school-age children is especially important, since children at that time have the highest risk of cavities. Most baby teeth are replaced by permanent teeth between 6 and 12 years of age, and new teeth can be misaligned if baby teeth are missing. Misaligned teeth, as well as new permanent teeth, are weaker than straight teeth and the teeth of adults, so the elementary school years are an important time for intervention.

The mean number of DMFT for 12-year-old children is an important benchmark of monitoring children's cavities worldwide. DMFT stands for decayed (untreated cavities), missing, and filled teeth (treated cavities). The World Health Organization (WHO) solicits data from member countries on DMFT, but not all provide it. Among those that do, WHO data suggest that DMFT for 12-year-old children tend to be lower in the African region (where there is less access to sugar and processed foods), and

higher in European and South American regions (Petersen, 2003). In developing countries, disadvantaged and poor population groups are at higher risk of cavities (Petersen, Bourgeois, Ogawa, Estupinan-Day, & Ndiaye, 2005).

A number of interventions have been developed to reduce cavities and improve oral health in children. A search of the Cochrane Database for review articles on "Dentistry & oral health," "Dental caries," and "Prevention" led to 19 articles summarizing literature on the effectiveness of different types of oral health interventions relevant to children, including systemic water fluoridation, topical fluoride (toothpaste, mouth rinse, gel, varnish), fluoride supplements, xylitol-containing products, pit and fissure sealants, dietary interventions, and behavioral interventions (Table 1).

Table 1. Cochrane reviews related to dental caries prevention

Intervention methods	N	Effectiveness*
Water fluoridation	155	+
Topical fluoride (toothpastes, mouth rinses, gels or varnishes)	144	+
Fluoride toothpastes of different concentrations	75	+ (>1,000ppm)
Fluoride toothpastes	74	+
Fluoride mouthrinses	36	+
Sealants	34	+
Fluoride gel	28	+
Fluoride varnishes	22	+
One topical fluoride vs. another	17	Null
Combinations of topical fluoride vs. single topical fluoride	12	△
Fluoride supplements (tablets, drops, lozenges or chewing gums)	11	+
Xylitol-containing products	10	+
Pit and fissure sealants vs. fluoride varnishes	8	X
Chlorhexidine vanish	8	X
One-to-one dietary interventions	5	+
Behavioral interventions	4	X
Fluoride for the prevention of early tooth decay	3	△
Slow-release fluoride devices	1	X
Milk fluoridation	1	+

Effectiveness*: +: Effective / △: Moderate effect / ×: Impossible to conclude

A systematic literature review of randomized control trials (RCTs) testing school-based interventions around the world yielded 26 articles testing a variety of interventions in 17 countries (Yasuda, unpublished). Ten of the interventions tested an education component, nine tested the effect of fluoride vanish, four tested tooth brushing, four tested Erythritol, Xylitol, Sorbitol, or Polyphenol gum or lozenge, two tested sealants, and single studies looked at the effectiveness of zinc syrup, dental hygienists in the schools, duraphat varnish, communication with parents, diet, counseling, and leaflets. Because almost every study measured success with a unique set of outcomes, no conclusions could be reached about the relative effectiveness of these interventions on cavity prevention. Rather, it appeared that researchers tended to test interventions that were relevant to their communities. For example low-cost educational interventions were tested in Nigeria, Pakistan, Thailand, Iran, China, Jordan, and Brazil, as well as in Switzerland and Sweden. Topical fluorides were tested in England, India, Turkey, and the Philippines, all countries without or with limited water fluoridation.

Thus, a country's cultural, political, and economic context dictates which interventions are tested and adopted. To understand and recommend the best interventions for different communities, it is important to understand the multilevel factors associated with child cavities at the family, school, community, and policy levels (Chi, 2013).

Focusing on a single nation is important to provide meaningful public health suggestions. This dissertation focuses on oral health care in Japan and of Japanese living abroad because I am from Japan and I am familiar with Japanese culture. In

Japan, I was a school nurse providing dental health education at a public elementary school for three years and a nurse taking care of serious dentistry patients at a national hospital for two years, Japan is a country without systemic water fluoridation. Oral health indicators have been improving over the years, but different prefectures have shown better improvement than others. I have concerns about risks of cavities among Japanese children and wish to better understand the problems and potential solutions for them.

Framework

My conceptual framework for this dissertation is a revised social ecological model. My model consists of six levels, which are oral health, child, family, school, community, and environment. In the basic social ecological model, several levels are overlapped like annual rings of trees in the way that bigger circles contain smaller circles respectively. However, in this revised model, family, school, and community are overlapped partially. The reason is because the relationships between the levels are more complicated than those of annual rings of trees in the real world. For example, there are children who do not have family support, there are families who are isolated from communities, and there are families that home-school their children. In this dissertation, multilevel factors were examined in their role to prevent cavities among Japanese children.

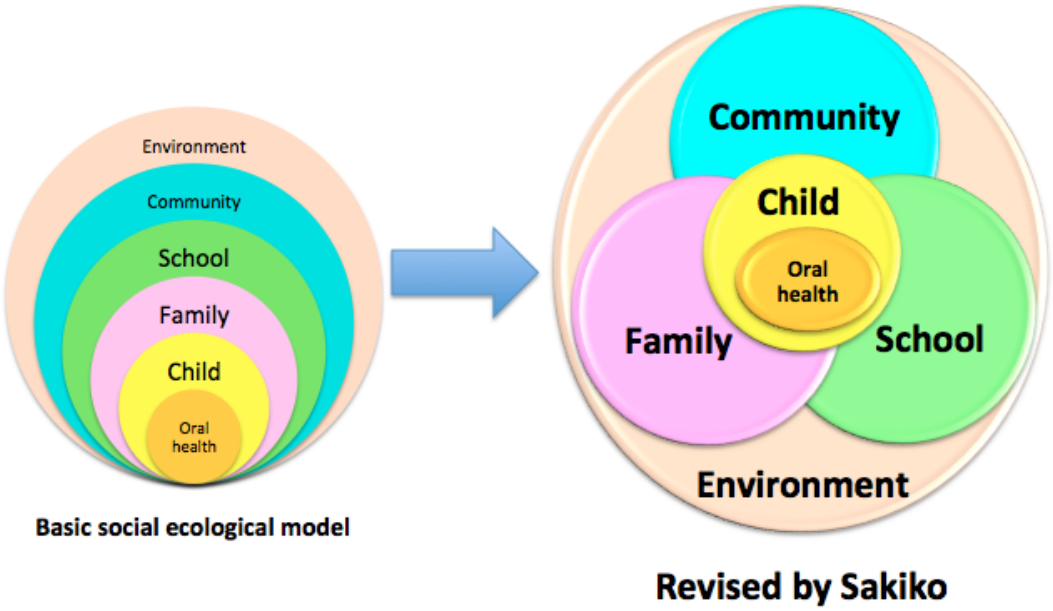


Figure 1. Conceptual framework of the study

Purpose and research questions

The objective of this dissertation is to understand multilevel factors in prevention of cavities among Japanese children. Research questions of three studies were the following.

1) What are the most effective school-based methods to prevent cavities of children in Japan?
2) What are the associations between child DMFT (Decayed, Missing, and Filled Teeth) and factors from the different domains of the conceptual framework in Japan?
3) What are the barriers and facilitating factors to prevent cavities in children of Japanese parents living in Hawai‘i?

CHAPTER 2

Abstract

The objective of this review is to summarize the existing published literature on the effectiveness of school-based interventions for preventing cavities in students in elementary schools in Japan. Two electronic databases, PubMed and CiNii (a database of scientific literature published in Japanese), were systematically searched. Studies were included if they: 1) were published between January 1, 2000 and December 31, 2013 in English or Japanese; and 2) reported the effects of an elementary-school-based, oral health intervention. Thirteen studies met the inclusion criteria. Twelve studies reported on the effectiveness of fluoride mouth rinsing (FMR) alone or in combination with oral health education and brushing teeth, and all twelve demonstrated the effectiveness of FMR in preventing cavities. Health education appeared to improve participation in FMR. Tooth brushing was effective if students used fluoride toothpaste, but not as effective as students participating in FMR. Although several studies tested the relative effectiveness of different concentrations and frequency of use of FMR, findings were inconclusive. Thus future research is needed in these areas.

Introduction

According to Healthy People 2020, “Good oral health is important for a person’s ability to speak, smile, smell, taste, touch, chew, swallow, and make facial expressions to show feelings and emotions (Healthy People, n.d.).” Also, loss of baby teeth before developing permanent teeth can negatively affect tooth alignment (Japanese Society of Pediatric Dentistry, 2013), and weaker or misaligned permanent teeth easily decay. Therefore, it is important to find effective interventions for elementary school students to prevent cavities.

According to OECD (Organization for Economic Co-operation and Development) Health Data 2009 (OECD iLibrary, 2013), the mean number of decayed, missing, and filled teeth (DMFT) for 12-years-old children in Japan in 2009 was 1.7. This figure almost is on par with the OECD countries’ average of 1.6. This represents great improvements in oral health in Japan compared to Japan’s average 4.0 DMFT 20 years ago (Ministry of Health, Labor and Welfare, 2013).

Japan is a country that did not introduce fluoridation in water nor salt, but nonetheless reduced DMFT drastically over the past 20 years. Thus, information on the types and effectiveness of cavity prevention interventions in Japan may be useful for countries with higher average DMFT for 12-year-olds. In addition, there are countries at a similar level of development as Japan but doing better. For example, in 2009, the mean DMFT for 12 year-olds was 0.7 in Germany and the United Kingdom and 0.8 in Denmark (OECD iLibrary, 2013). Thus, Japan has the potential of improving oral health by providing more effective and earlier prevention interventions.

In Japan, where methods for systemic fluoride application, such as through water fluoridation, have not been implemented, many school-based interventions have been introduced to improve oral health in children. For example, since 1958, annual dental examinations have been mandatory for all students at elementary school, junior high school, and high school, due to the passage and enforcement of Japan's School Health and Safety Act. During the first semester between April and June of every year (in Japan, the school year runs from April to March of the following year), school dentists are scheduled to give dental examinations at each school. If students are diagnosed with a need for dental treatment, school teachers send letters with treatment recommendation to their parents immediately. In the case of students on welfare and school-expense subsidies, the general treatment fees for dental care provided at hospitals and clinics in Japan are waived. In addition, dental examination records of each student are stored at the school up to five years after graduation. Even in the case of students who transfer schools, the records are carried from school to school until five years after the student graduates from high school.

To further support child oral health, in most elementary and junior high schools in Japan, except private schools, there are no vending machines on campus, and most students are prohibited from buying food between school and home. Moreover, 98.1% of the elementary schools (Ministry of Education, Culture, Sports, Science and Technology, 2013) provided well-balanced school lunches for all students in 2010. These regulations and supports aim to assure that students eat the healthy school lunch. In terms of oral health interventions, some schools schedule a block of time for brushing teeth after lunch, some encourage students to regularly rinse their mouths with

school-provided fluoride mouth rinse, and others provide health education or combine several types of interventions.

Although the mean DMFT for 12 year-old students in Japan has been dramatically decreasing (Ministry of Health, Labor and Welfare,2013), there is no systematic review examining the effectiveness of oral health interventions for elementary school students in Japan. This paper presents methods and findings of a systematic review of these interventions, drawing from the English- and Japanese-language scientific literature. Findings from this review can promote more effective interventions in Japan and provide evidence-based information for other countries that want to reduce cavities in elementary-school-age children.

Methods

Two electronic databases for the scientific literature, PubMed for English-language literature and CiNii for Japanese-language literature, were systematically searched between September 17 and December 31, 2013. The terms used to find articles are shown in Table 2.

Table 2. Keywords categories used

Resource	Search Term	Found	Retained (Duplicate)
PubMed	Japan AND School-based	4	1 (0)
	Japan AND Dental AND Elementary school	30	3 (0)
	Japan AND Community-based	63	0
	Japan[mesh] AND Dental caries[mesh] AND (elementary school* OR primary school*)	19	5 (0)
CINii	*shogakko ha*	326	41 (0)
	shogakusei ha	147	2 (6)
	shogakkou ushi	70	1 (27)

	jido ushi	63	6 (13)
	shogakusei ushi	23	0 (3)
	shogakkou mushiba	2	0
	shogakusei mushiba	1	0
	jido mushiba	5	0
Total		753	59

Search terms in PubMed included Japan, school-based, community-based, dental, dental caries, elementary school, and primary school. Terms used to search Japanese articles in CiNii were all Japanese, *shogakko* (= elementary school* OR primary school*), *shogakusei* or *jido* (=elementary school student*), *ha* (=tooth [mesh]), and *ushi* or *mushiba* (=cavity* [mesh]). When several terms were used to search articles, including the terms in PubMed, “AND” was used, but in CiNii “space” was used between terms.

For inclusion, studies needed to: (1) report on the effects of oral health interventions conducted at elementary school in Japan, targeting elementary school students (6-12 years old); (2) aim at the prevention of cavities; (3) be published from January 1, 2000 to December 31, 2013 in peer-reviewed journals; (4) report effects on behaviors, skills, knowledge, and/or outcomes related to prevention of cavities; and (5) be written in Japanese or English. There were no restrictions on study design, intervention duration, follow-up period, intervention strategies, or sample size.

Interventions with special-needs children were excluded because each special-needs child has significantly different needs, and the interventions for these children are not generally applicable for the majority of students, although it is very important to study interventions for them. Studies appearing in journals or reports published by universities or junior colleges were also excluded because they usually restrict authorship to current students, graduates, and faculty members from these institutions,

and peer review may be limited. Studies published before 2000 were excluded because oral hygiene practices and trends that may influence them—for example, lifestyle, dietary habits, parental attitudes, and education trends—have changed over time.

To identify the relevant studies, the author first screened titles and abstracts. The full article was read if it appeared to meet the criteria, if there was no abstract, or if it was unclear by reading the title and abstract if it was relevant. All articles that were not available online were requested through inter-library loan from the University of Hawaii.

Results

Details from the search are shown in Figure 2. In all, 753 articles were identified and screened, and 695 articles were excluded because they were not relevant.

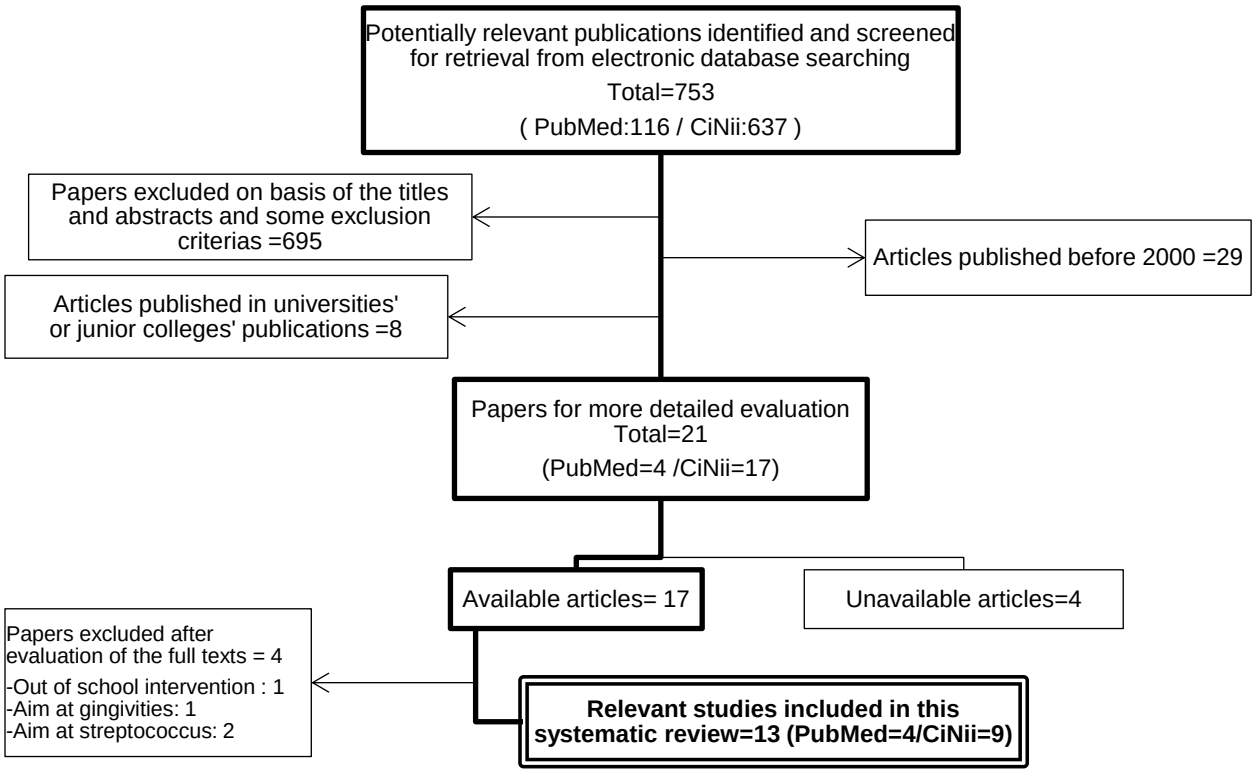


Figure 2. Flow chart of study selection process

Among the remaining 58, 29 were published before 2000, and eight appeared in a university or junior college publication. Of the remaining 21, three were obtained online, 14 were obtained through inter-library loan, and four were unavailable. Among the 17 obtained articles, four articles were excluded, one because the intervention was not in a school setting and three because the study aims were not related to preventing cavities.

Thirteen studies were included in the present review, and all studies examined the impact of interventions conducted at elementary schools. The study characteristics of each included study can be found in Table 3. Six studies collected data only at elementary schools (Imaue et al., 2005; Inaba et al., 2002; Ishizu et al., 2001; Ohashi et al., 2008; Sato, 2010; M. Yamamoto, Hirayama, Tsutsui, & Haresaku, 2007), two collected data at elementary and junior high schools (Ohara, Kawaguchi, Shinada, & Sasaki, 2000; Yoshioka et al., 2005), three collected data only at junior high schools (Iida, Suetaka, & Ishii, 2002; E. Komiyama, Kimoto, & Arakawa, 2012; Yagi, Sakuma, Kishi, Okada, & Miyazaki, 2006), and two studied data of adults (Isozaki, 2000; Neko-Uwagawa, 2011). The reason that many studies examined data of non-elementary school students was to evaluate the long-term effect of interventions administered in elementary school. Study population size varied from 115 to 5,650 individuals and from 1 to 237 schools.

Table 3. Study characteristics of included studies

#	First author (Year)	Location (Prefecture)	Sample	Study Design	Age	Duration (Years) of interventions		Intervention
						Case	Control	
1	Ohara (2000)	Iwate	2867	Cohort	6-14	0-4 for intensive treatment / 7 for FMR*		Weekly FMR*(900ppm) / Intensive dental treatment / Oral health education
2	Neko-Uwagawa (2011)	Niigata	637	Cohort	20-39	6 / 11	0	Daily FMR(500ppm) / Weekly FMR(2000ppm)
3	Yagi (2006)		115	Cohort	12-13	6	0 <1.5	Weekly FMR(900ppm)
4	Iida (2002)		237 schools	Cohort	12-14	6 / 9	0	FMR
5	Ohashi (2008)	Gifu	622	N-RCT	6-11	6	0	Daily FMR(250ppm) / Brushing
6	Ishizu (2001)		163	N-RCT	6-10	4	4	FMR(100ppm) / Brushing (100ppm) /Brushing (No fluoride)
7	Isozaki (2000)		368	Cohort	20	6		Daily FMR (500ppm)
8	Sato (2010)	Okayama	256	N-RCT	8-9	0.3		Oral Health education
9	Imaue (2005)	Kagawa	5650	N-RCT	6-11	6		Weekly FMR(900ppm) / Brushing / Weekly oral health education
10	Yoshioka (2005)	Tokushima	209	N-RCT	6-14	6-8	0-5	Daily FMR(250ppm) / Dental examination twice a year /
11	Inaba (2002)	Nagasaki	600	Cohort	6-11	2-5 / 3	0	Daily FMR(112.5 / 225ppm)
12	Yamamoto (2007)	Okinawa	450-550	Cohort	9-11	3	3	Weekly FMR / Oral health education
13	Komiyama (2012)	-	881	Cohort	12	6	< 1	Weekly FMR(900ppm)

*FMR = Non-prescriptions Fluoride Mouth Rinse after school lunch during 10-month school year. (Daily = 5 times /week Weekly = 1 time / week)

*APF = Acidulated Phosphate Fluoride = Painting of teeth with fluoride by a dentist

Six studies used an ecological study design, comparing schools or groups of students with different interventions (Iida et al., 2002; Inaba et al., 2002; Ishizu et al., 2001; E. Komiyama et al., 2012; Ohashi et al., 2008; M. Yamamoto et al., 2007). Three studies used a cross-sectional study design, comparing individual students who joined different interventions (Isozaki et al., 2000; Neko-Uwagawa, Yoshihara, & Miyazaki, 2011; Yagi et al., 2006).Three studies used historical cohort study designs, analyzing data on the same students for several years (Imaue et al., 2005; Ohara et al., 2000; Yoshioka et al., 2005). One study used a quasi-experimental study design, conducting a pre and posttest at one school (Sato, 2010). The duration of interventions varied greatly between studies, from a minimum of few months to a maximum of 11 years. The time frame over which analyzed data had been collected also varied, from few months to 20 years.

Twelve studies, all excepting Sato (2010), focused on FMR (Fluoride Mouth Rinsing), including five studies testing combination interventions, such FMR with brushing teeth (Imaue et al., 2005; Ishizu et al., 2001; Ohashi et al., 2008), FMR with oral health education (Imaue et al., 2005; Ohara et al., 2000; Sato, 2010; Yamamoto et al., 2007), FMR with intensive oral health treatment (Imaue et al., 2005; Ohara et al., 2000), and/or FRM with additional oral health examinations (Inaba et al., 2002).

Since all elementary to high schools in Japan have to provide annual dental checks by school dentists and the records of each student are stored at schools, eleven studies used school data for annual or continuous evaluation of their interventions--all studies except those by Sato (2010) and Yamamoto (2007). Four studies, including two studies that used dental records, administered questionnaires to evaluate their interventions. Eleven studies used DMFT values calculated from the records as a measure, and two studies, Sato (2010) and Yamamoto (2007), used data from only questionnaires for evaluation, measuring for example a student’s skill and motivation for maintaining good oral health or participation for FMR.

FMR

All twelve studies that tested FMR as an intervention at elementary schools demonstrated its effectiveness in preventing cavities. Based on data reported, students who participated in FMR at elementary schools for six years had 37-75% fewer cavities than students that did not participate in FMR. This review also suggests that the effect of participating FMR at elementary schools continues to protect the teeth of the participant into adulthood (Isozaki, 2000; Neko-Uwagawa, 2011).

Several studies tested different concentrations of FMR and different patterns of use. Figure 3 presents the distribution of the relationship between reduction rates of cavities, fluoride concentration, and frequency of use in each study. Data from three studies (Ohashi et al, 2008; Sato et al, 2010; Yamamoto et al, 2007) were not shown in the figure. The reasons are because Ohashi focused on differences by brushing teeth at schools providing FMR, Sato's intervention did not include FMR, and Yamamoto focused on improving participation in FMR by education. The Yellow data point is for the study by Iida et al. (2002), in which the data about concentration and frequency was unclear. Blue data points are for studies that provided data of daily FMR use by students. Green data points are for studies that provided data of weekly FMR use by students. Arrows are used for two studies (Neko-Uwagawa et al, 2011 & Inaba et al, 2002) to show the connections of data points over time. A study by Neko-Uwagawa provided both daily and weekly FMR, and a study by Inaba provided a wide range of cavity reduction rates in their results.

The figure shows different cavity reduction rates for studies that administered FMR with similar frequency and fluoride concentration. No studies compared the effect of different frequency of FMR use. The effect of different concentrations of fluoride was analyzed by only one study (Inaba et al, 2000), which showed similar outcomes for different concentrations (112.5 ppm and 225ppm daily FMR) at a same school. It may be that other factors, such as FMR participation rates and other interventions provided with FMR, may affect cavity reduction. However, limited information on participation rate or contents of health education was provided in the articles.

Table 4. Outcome by FMR

Study #	Reduction rate of cavities	Frequency	Concentration (ppm)	Participation rate	Duration (Year) of interventions		Age		Other interventions
					Case	Control	Intervention	Evaluation	
1	44.1% Before-after	Weekly	900	99.9%	7	No control	6-14	6-14	Dental treatment Education
2	66% Case-control	Daily Weekly	500/2000	—	6 / 11	0	4-14	20-39	—
3	48.3% Case-control	Weekly	900	96-97.2%	6	0 / < 1.5	6-11	12-13	—
4	42% Case-control	—	—	—	6 / 9	0	6-14	12-14	—
5	0% Case-control	Daily	250	—	With brushing teeth	Without brushing teeth	6-11	11	Brushing teeth
6	75% Case-control	Daily	100	—	4 (FMR)	4 (Brushing teeth)	6-9	6-9	Brushing teeth
7	24-27% Before-after	Daily	500	—	6	No control	6-11	20	—
9	65% Before-after	Weekly	900	98%	6	No control	6-11	11	Brushing teeth Education
10	56% Before-after	Daily	250	—	6-8	No control	5-14	6-14	Additional examination
11	0%, 22-66% Case-control Before-after	Daily	112.5/225	—	2-5 / 3	0	6-11	6-11	—
12	Participation rate (+) Case-control	Weekly	—	61.1%	3 (More education)	3 (Less education)	4?-14	9-11	Education
13	36.6% Case-control	Weekly	900	—	6	< 1	6-11	12	—

- Study #: #8 is excluded because they did not include FMR in the intervention.
- Frequency: Daily means 5 times per week and weekly means 1 time per week
- Concentration: Fluoride concentration in mouth-rinse-water (ppm = parts per million 1ppm = 0.0001%)
- Participation rate: Rate of students who participated in FMR among all targeted students
- Age: Age of students when they participated in FMR and when they were evaluated effects of intervention
- "—" means no information

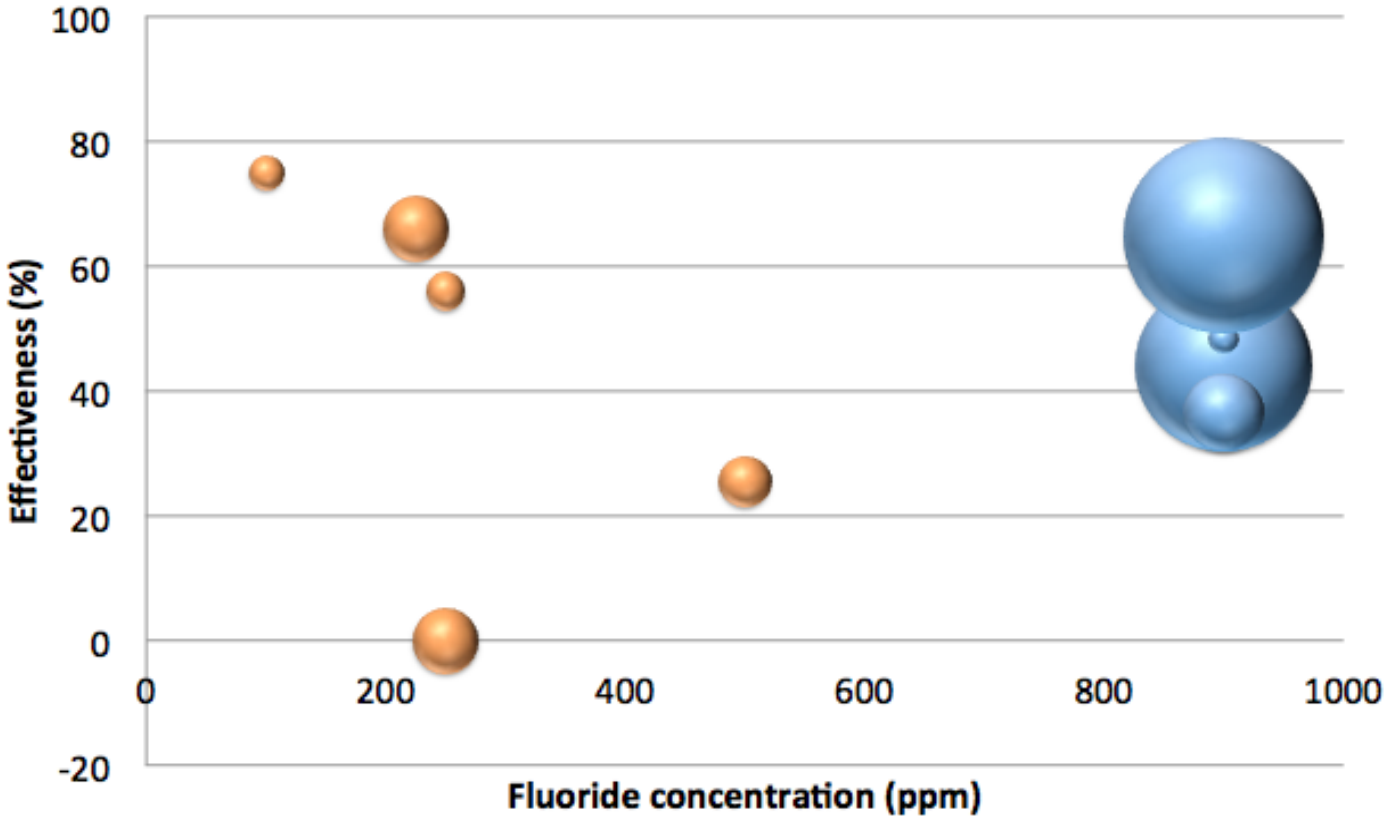


Figure 3. Distribution of relationship between reduction rates of cavities, fluoride concentration, and frequency

- Orange dots: Daily FMR (Study # 5, 6, 7, 11) / Blue dots: Weekly FMR (Study #1, 3, 9, 13)
- Size of dots = population size
- Results in 4 studies are not included due to combination of FMR frequency (#2), no information about concentration and frequency of FMR (#4), no FMR intervention (#8), and results focusing on participation rate for intervention (#12)

Oral health education

Four studies offered oral health education as part of their intervention. One study (Yamamoto et al., 2007) compared an intervention providing FMR only with an intervention providing FMR and oral health education; the findings suggested that those children that also received the education had a higher rate of participation in FMR (Yamamoto, 2007). Another study of education and FMR showed a reduction in cavities when FMR was provided with education and an increase when education was stopped (Imaue, 2005). Specifically, the researcher provided oral health education from 1997 to 2000 and 2003 to 2004, with an unexpected interruption due to her own health issues. Although DMFT continuously decreased from 1997 to 2000, it increased in 2001 and 2002 when she could not provide education, and decreased again from 2003 when she restarted oral health education. Sato (2010) used a pre-posttest design to test her educational intervention and showed that it had a positive effect on students' motivation to improve their knowledge and skills related to oral health.

Brushing teeth

Three studies tested tooth brushing. Two studies used tooth brushing as an additional intervention to FMR (Ishizu et al., 2001; Ohashi et al., 2008), and one study compared the effectiveness of tooth brushing against providing FMR (Imaue, 2005). Ohashi (2008) showed no difference in cavities between schools encouraging FMR and tooth brushing and schools encouraging FMR only. Ishizu (2001) compared students in three school—one that offered daily FMR, one in which students brushed teeth with fluoride toothpaste, and one in which students brushed teeth without fluoride toothpaste. The best outcome was at school with FMR, followed by the school in which students brushed with fluoride toothpaste. Imaue (2005) provided brushing teeth as part of their interventions, but did not report on its effect. Since there was no study that compared tooth brushing and no intervention, effect of tooth brushing alone in Japan schools is not known.

Discussion

This review had three major findings. The first finding is that using FMR at school is effective in reducing DMFT. Although further research is needed to evaluate the most effective concentration of fluoride and frequency of intervention, all studies that examined FMR found it significantly associated with reduced number of cavities. Thus, the effectiveness of requiring students to use FMR in schools in Japan is well established.

The second finding is the importance of oral health education. According to four studies (Yamamoto et al, 2007; Ohara et al, 2000; Imaue et al, 2005; Sato, 2010), oral health education not only improves knowledge and motivation, it can increase participation in use of FMR. Imaue (2005) showed the importance of oral health education clearly. Although she had introduced FMR from the beginning of intervention duration, for four years when she provided oral health education as additional intervention to FMR, DMFT continuously decreased more from about 1.2 to 0.2. The following two years when she could not provide education, DMFT rate increased from about 0.2 to 1.1. When she restarted providing education, the rate decreased again. Yamamoto (2007) showed that students who had more chances to learn oral health in smaller groups increased participation rate for FMR. Since education raises the participation rate and improves understanding of oral programs, FMR in combination with oral health education is more effective than FMR only. Although two studies (Yamamoto et al, 2007 & Imaue et al, 2005) mentioned the effect of oral health education by dentists, it is not always a practicable intervention due to the cost of hiring dentists. Also, not all of the dentists have good abilities and motivation to educate, especially elementary school children in school settings. Therefore, what must be examined should be who can deliver the most effective education, and what kind and dose of education is most effective to enhance more positive effect.

The third finding is the importance of community education on the benefits of FMR. Although the number of schools that offer an FMR program has been increasing (Kimoto et al, 2006), a 2008 survey showed that only 5.1% of students aged 4-15 in Japan were participating in FMR at school (Kimoto et al, 2009). Also, the survey

showed great differences in the execution of FMR programs across regions in Japan. Therefore, the Ministry of Health, Labor and Welfare published a national guideline, the Guideline on Fluoride-Mouth-Rinsing (2003), and sent it to all provincial governors in Japan to recommend FMR. The official guideline suggested to start FMR at age four, and to continue as long as possible.

However, many people still oppose FMR at schools in Japan. For example, in 2011, the Japan Federation of Bar Associations submitted a statement calling for the cancellation of school-based fluoride programs (Japan Federation of Bar Associations, 2011) to the Minister of Education, Culture, Sports, Science and Technology, the Minister of Health, Labor and Welfare, and the Minister of Environment. They opposed school-based fluoride program because of safety issues, uncertain effectiveness of intervention, lack of follow up surveys, and environmental pollution. Most of their concerns seemed to be from lack of access to accurate scientific evidence, bias against fluoride, and confusion between fluoridation of tap water and topical fluoride programs such as FMR. Therefore, it is very important to enlighten Japanese citizens about the benefits of FMR by providing understandable oral health education for not only students but also for teachers, parents, and communities.

In addition, since limitation of facilities and manpower at schools regulate interventions, such as FMR or brushing teeth, governmental support is needed to secure a sufficient budget to improve facilities and personnel. With such supports, effective intervention such as FMR can be conducted continuously to prevent cavities for more children in Japan. Although no paper discussed cost-effectiveness of FMR, larger interventions, such as prefectural or national interventions, would decrease the cost per person to conduct FMR.

Limitation

Two-thirds of the papers included in this review were in the Japanese language. Although there were many convincing publications in Japanese, obtaining articles published in Japanese requires time and effort, and not all Japanese-language publications identified in CiNii were retrievable. Also, Japanese-language papers are

difficult for most non-Japanese to read. These facts may make it difficult for a U.S. author to replicate this review. Second, the articles generally provided limited information on the intervention, especially interventions providing oral health education. Two articles (Isozaki, 2000 & Ishizu 2001) were only two pages long each, Third, most of the studies showed positive outcomes. This may represent publication bias, as studies that could not show effectiveness might not have been published, or authors might not have tried to publish their findings. Fourth, most of the studies focused on FMR. No studies were found examining other interventions commonly provided at elementary schools in Japan, such as plaque-disclosing solution and follow-up for annual oral health examination, as well as oral health education by dental hygienists and education using mirrors. No study looked at the effects of gum or candy interventions, because they would never be introduced at schools in Japan where eating snacks are prohibited. In addition, most of studies, excepting Sato (2010), did not survey behaviors at home, although students' customs at home might have an effect on the outcome of interventions.

Conclusion

In conclusion, school-based oral health interventions involving FMR from age 4 through age 14 effectively reduces DMFT in children, and benefits (less cavities) last into adulthood. However, it is very important to provide continuous oral health education to explain the effectiveness and safety of FMR to people, including students, teachers, parents, and policy makers

CHAPTER 3

Abstract

The objective of this study is to analyze factors related to cavities among children in Japan. This secondary data analysis used publicly available data for 47 prefectures published for 2011, 2012, 2013, and 2014.

Data were available on potentially 600+ variables, of which 170 variables were selected based on best fit with the conceptual model. Correlation was used to reduce the 170 variables to 18 most highly correlated variables with DMFT of 12-year old children. Data across multiple years (if available) were averaged, and correlation used to further reduce the variables to six.

After testing for multicollinearity, three prefecture-level variables were included in the model, which predicted approximately 50% of DMFT in 12-year old children. These were average income per person, numbers of school-age children (from preschool to junior-high school) who participated in school-based FMR programs per 100 students, and numbers of convenience stores per 100,000 persons.

Among the three variables, increasing the participation rate for FMR seemed to be the most feasible way to reduce DMFT of 12-year-old children in the context of Japan without systemic water fluoridation.

Introduction

Cavities can have a negative impact on person's life. For example, they can decrease academic performance, physical ability, and quality of life (Petersen, 2003); they can limit one's diet; and they are associated with dementia (T. Yamamoto et al., 2012). Having good oral health is also important to prevent periodontal diseases, also called as gum diseases, which are caused by bacteria and are associated with diabetes, cardiac diseases, brain infarction, and immature birth (Centers for Disease Control and Prevention & National Center for Chronic Disease Prevention and Health Promotion (U.S.), Division of Oral Health, 2011). Since cavities in childhood can cause irreversible negative damage over the life course, it is necessary to prevent and treat

cavities in children. Because several factors are associated with cavities, it is important to study the relationship between factors to improve child oral health status.

The mean number of DMFT for 12-year-old children is an important benchmark of monitoring children's cavities worldwide. DMFT stands for decayed (untreated cavities), missing, and filled teeth (treated cavities). The World Health Organization (WHO) solicits data from member countries on DMFT, but not all provide it. Among those that do, WHO data suggest that DMFT for 12-year-old children tend to be lower in the African region (where there is less access to sugar and processed foods), and higher in European and South American regions (Petersen, 2003). In developing countries, disadvantaged and poor population groups are at higher risk of cavities (Petersen et al., 2005).

The number of average DMFT for 12-years-old children has been decreasing in Japan, and it was 1.0 in 2014, the lowest in the national records. It means that, on average, a 12-year-old child has one decayed, missing, or treated tooth. It represents great improvements in oral health compared to 4.75 in 1984 (Japan Ministry of Education, Culture, Sports, Science and Technology, 2015). However, there are countries at a similar level of development as Japan that are doing better. For example, according to the data from the Organisation for Economic Co-operation and Development (OECD), the mean DMFT for 12 year-olds is lower in Denmark (0.6), Luxembourg (0.6), the United Kingdom (0.7), Finland (0.7), Germany (0.7), the Netherlands (0.9), Sweden (0.9), Switzerland (0.9), Belgium (0.9), and Portugal (0.9) (Organisation for Economic Co-operation and Development, 2015). Although differences may seem small, these data suggest that Japan has the potential to improve oral health.

Also, there are disparities across prefectures in Japan, from a high of 2.2 DMFT for 12-year-old children in Okinawa to a low of 0.5 in Niigata in 2014. There are 47 prefectures in Japan, and the unit has been stable after Okinawa was returned from the United States (US) in 1972. In general, prefectures are geographically smaller than US states (8,041 vs. 192,560 square kilometers on average, respectively) but have greater population density (336 vs. 33 persons per square kilometers on average, respectively).

One of the reasons why Japan's DMFT is higher than the DMFT in several other OECD countries may be that Japan does not have systemic fluoride application, such as through water fluoridation, salt fluoridation, or milk fluoridation. However, a school-based fluoride mouth rinse program was launched in Niigata Prefecture in 1970 and expanded to all 47 prefectures in Japan by 2005 (Non-profit Japanese Conference on the Promotion of the Use of Fluoride in Caries Prevention, 2013).

Previous research outside of Japan suggests risk factors for higher child DMFT, such as higher sugar consumption (World Health Organization, 2015), lower income (Data Resource Center for Child & Adolescent Health, 2007), being uninsured (Cruz, Chen, Salazar, Karloopia, & LeGeros, 2010), and immigrant status (Data Resource Center for Child & Adolescent Health, 2007). However, these factors may not be associated with DMFT in Japan because the average rate of sugar consumption is much lower than other developed countries (World Health Organization, 2015), the Japanese health care system provides universal health coverage and free dental care for children from low-income families, and only 1.7% of populations are foreigners (Japan Ministry of Justice, 2015).

According to the other previous research, the positive effect of the school-based program both by school and by area is significant (Iida et al., 2002; Imaue et al., 2005; Inaba et al., 2002; Ishizu et al., 2001; Isozaki et al., 2000; E. Komiyama et al., 2012; Neko-Uwagawa et al., 2011; Ohara et al., 2000; Yagi et al., 2006; Yoshioka et al., 2005). The Japan Ministry of Health, Labor and Welfare sent an official guideline to each governor to encourage implementing school-based fluoride mouth-rinse programs, with notification about the positive effects in group-settings such as schools for children age 4 to 14 (Japan Ministry of Health, Labor and Welfare, 2003). Recent research shows that the number of children joining such programs in school has been increasing in Japan, reaching 1,044,254 in 2014 (Kimoto et al., 2014). However, this number represents less than 10% of school children. Even though there is at least one school providing FMR program in all prefectures, not all schools provide the program and not all students at participating schools participate in school programs.

This study aims to uncover possible reasons for disparities across prefectures in Japan for DMFT, as well as suggestions for improving oral health care for all children in Japan. This exploration is facilitated by availability of data published by the Japanese government by prefecture on DMFT and a range of family, school, and community indicators. Since 1948, the Ministry of Education, Culture, Sports, Science and Technology has been publishing information related to cavities of children every year. However, the units and categories of data have been changing. Between 1948 and 1983, dental data was published as the percentage of children who had cavities by prefecture or area, by gender, and by age. Between 1984 and 2005, data about average DMFT for 12-year-old children was additionally published by gender. Since 2006, average DMFT for 12-year-old children has been published by gender and prefecture. For example, in the capital prefecture, Tokyo, the average DMFT for 12-year-old-boys was 0.9 compared to 1.1 for girls in 2013 (Ministry of Education, Culture, Sports, Science and Technology, Japan, 2014).

Because of Japan's School Health and Safety Act in 1958 (Japan Ministry of Education, 2015), annual dental examinations are mandatory for all students from first grade to tenth grade. Assigned local dentists visit every elementary, junior-high, and high school in Japan every year to provide dental check-ups for students. They provide screening for all students individually at schools, assessing dental cavities, malocclusion, dental plaque, and gingival status. The Ministry uses stratified cluster sampling to gather DMFT data representative of each prefecture. These nationwide data are published every year online.

The Japanese government also regularly publishes information about other social factors by prefecture. For example, the Cabinet Office publishes data on average income per capita, and the Ministry of Health, Labor and Welfare publishes data on dental clinics or dentists per 100,000 persons. A non-profit organization publishes the ratio of children per prefecture who participate in school-based fluoride mouth rinsing program (Komiyama, Kimoto, Taura, & Sakai, 2014). The availability of these data allows the testing of associations between such socio-ecological factors and child DMFT.

Therefore, given the uniqueness of social structures in Japan, this study examined the associations between various socio-ecological factors and child DMFT by prefectures using secondary data analysis to see if the same factors seen in other locations are relevant in Japan.

Methods

This is a secondary data analysis to test the associations between child oral health indicators (operationalized by DMFT) and available data representing the family, school, and community domains of the conceptual framework. The dependent variable for the analysis was DMFT per prefecture in child domain. The process of selecting specific independent variable for this analysis is described below.

Japanese Ministries published datasets by various units such as prefecture, gender, and size of cities. The number of datasets published by gender is limited. Those published by size of cities note that population sizes change over time due to migration, growth, and municipal mergers. Therefore, this study used publicly available data by prefecture to study the associations between child oral health and social factors comparing prefectural differences. The datasets were gathered into an Excel spreadsheet and then imported into and analyzed using SPSS software (version 23).

As noted, the dependent variable for this analysis is DMFT. Since DMFT datasets were created by stratified cluster sampling, there may be some annual fluctuations in the numbers, likely due to sampling error. Therefore, before analysis, DMFT for the years 2010, 2011, 2012, and 2013 were averaged for each prefecture. Then, the average number of DMFT per children in each prefecture was multiplied by 100,000 so that findings could be expressed in average DMFT per 100,000 children. Note that DMFT data are missing in 2011 for the three prefectures severely affected by the Great East Japan earthquake and tsunami on March 11, 2011. For these prefectures, only three years of data were averaged.

Since more than 15 sample units are needed per parameter in linear regression (Harrell, 2001), only 3 or less parameters could be used with a sample size of 47 prefectures. To choose the independent variables for the final equation model, there

was a four-step process. In step-one, 170 prefectural variables were considered from over 600 prefectural variables from 28 datasets. The 170 variables were selected based on the possibility of relationship to oral health condition of children as outlined in the conceptual model and previous research. For example, research suggesting the link between family socioeconomic status and DMFT led to the testing of a variety of variables representing family socioeconomic status, like mean income, mean savings, percent households on welfare, dual-income households, and so forth (all of which are likely to be highly corrected) to identify the best one to include in multivariate analysis.

In line with the conceptual model, community variables were examined as well. For example, although the number of convenience stores per population has not been linked to DMFT, a high density of convenience stores may indicate easy access to sugary drinks and snack foods for neighborhood children.

Data were gathered through publicly available on websites of four government agencies--the Ministry of Education, Culture, Sports, Science and Technology (Ministry of Education, Culture, Sports, Science and Technology Japan, 2015), the Ministry of Internal Affairs and Communications(Ministry of Internal Affairs and Communications, 2015), the Ministry of Health, Labor and Welfare (Ministry of Health, Labor and Welfare, 2015), and the Cabinet Office (Cabinet Office, Government of Japan, 2015) in Japan. To increase the reliability of data, datasets published by non-governmental organization were excluded with one exception. A group named Non-profit Japanese Conference on the Promotion of the Use of Fluoride in Caries Prevention published data on the percentage of students by prefecture who participated in school-based fluoride mouth rinsing (FMR) programs in 2010 (Komiyama et al., 2014). The reason to include these data is because FMR programs have been shown to be very effective as reducing DMFT in school children in Japan in the absence of systemic fluoride application through water, salt, or milk fluoridation (Yasuda, 2014).

In step two, the 170 prefectural variables in the three domains—family, school, and community—of the conceptual framework thought to be associated with DMFT were correlated with DMFT. Because all variables were continuous, Pearson's

correlation was used to test association with DMFT. The 18 variables across the three domains with the highest correlation coefficients were selected for further consideration.

In step three, the available data for each of the 18 variables were averaged. For example, data on welfare expenditures for children were available in 2010 and 2012, so data from these two time points were averaged. In comparison, data on high school graduates going on the further education was available for 2010, 2011, and 2012, so data from these three time points were averaged. These means were correlated with DMFT. In this step, correlation was used to test associations for all 47 prefectures and for 44 provinces (excluding the three prefectures with only three years of DMFT data due to the tsunami). In addition, correlation was done between each independent variable and the components of DMFT, including decayed teeth (D), missing teeth (M), and filled teeth (F). Six variables with the highest correlations coefficients were selected for further consideration.

In step four, these six variables were tested for multicollinearity using the scatterplot function of SPSS and calculating the tolerance before inclusion in regression models. Regression diagnostics were studied, and several possible regression models were compared. Among limited predictors, normality of error distribution and outliers also were evaluated. Then, a final multiple-regression model including DMFT as the dependent variable and the three most predictive variables from the family, school, and community domains as independent variables was estimated.

Results

Among the 170 possible variables, the six variables in each domain (a total of 18 variables) that were highly correlated with the average DMFT of 12-year-old children were selected for further analysis (Table 5). Since the number of subjects was relatively small (n=47 prefectures), initially only one variable with the highest correlation to the average DMFT for each domain was chosen—average income per person in the family domain ($r = - 0.440$), numbers of high school graduates going to further education per 100 graduates in the school domain ($r = - 0.506$), and numbers of convenient stores per 100,000 persons in community domain($r = - 0.456$)—for inclusion in multivariate models.

In addition to these three independent variables, three additional independent variables—participation rate of school-based fluoride mouth rinsing programs, population of foreigners, and numbers of dental clinics—were examined for possible inclusion because they are significant and different features to the other three independent variables. These additional variables were chosen because FMR programs have been shown to be very effective as reducing DMFT in school children in Japan (Yasuda, 2014), foreigners are high risk population of cavities (Cvikl et al., 2014; Pollick, Rice, & Echenberg, 1987), and institutional disparities like the numbers of dental clinics may affect the DMFT of children.

Table 5. Statistically highly correlated variables in each domain

Domain	Variables	Publisher	Availability of dataset[g)]			
			2010	2011	2012	2013
Child oral health	Numbers of DMFT[a)] of 12-year-old children (per 100,000 students)	Ministry of Education, Culture, Sports, Science and Technology	○	△	○	○
	Numbers of decayed teeth[b)] of 12-year-old children (per 100,000 students)		○	△	○	○
	Number of missing teeth[c)] of 12-year-old children (per 100,000 students)		△	△	○	○
	Number of filled teeth[d)] of 12-year-old children (per 100,000 students)		○	△	○	○
Family	Income (per person,1000 yen)	Cabinet Office	○	○	○	
	Outstanding post-saving (per person)	Ministry of Internal Affairs and Communications	○			○
	Households assisted by livelihood protection (per 1,000 households)		○		○	
	Welfare expenditure for 0-17 -year-old children (per person)		○		○	
	Family nuclei households (per 100 households)		○			
	Dual-income households (per 100 households)		○			
School	People having completed up to elementary or junior high school only (per 100 persons)		○			
	People having completed up to high school only (per 100 persons)		○			
	People having completed up to junior colleges or equivalent (per 100 persons)		○			
	People having completed up to colleges and universities (per 100 persons)		○			
	High school graduates going to further education (per 100 graduates)	Ministry of Education, Culture, Sports, Science and Technology	○	○	○	
	School-age children (from preschool to junior-high school) who participated school-based FMR[e)] program (per 100 students)	Non-profit organization[f)]	○			
Com-munity	Population (per 1km^2 of inhabitable area)	Ministry of Internal Affairs and Communications	○			○
	Population of foreigners (per 100,000 persons)		○			
	Convenience stores (per 100,000 persons)			○		
	Food and drink stores (per 1,000 persons)			○		
	Eating and drinking places (per 1,000 persons)			○		
	Dental clinics (per 100,000 persons)	Ministry of Health, Labor Welfare	○		○	

a) DMFT = Decayed, Missing, and Filled Teeth
b) Decayed teeth = Untreated teeth
c) Missing teeth = Missing teeth due to cavities
d) Filled teeth = Treated teeth
e) FMR = Fluoride Mouth Rinsing
f) Non-profit organization = Non-profit Japanese Conference on the Promotion of the Use of Fluoride in Caries Prevention

g) ○: Data from all 47 prefectures were available △: Data were partially unavailable

There are similar datasets published every year.
(e.g. Population per prefectures and numbers of clinics per prefectures are published every year. But population per inhabitable area and clinic per 100,000 persons are published in limited years.)

Table 6. Correlation between dependent variable (DMFT) and independent variables

Domain	Variables	DMFT (n=44)[1)]	DMFT (n=47)
Family	Income	-.436**	-.440**
	Outstanding post-saving	-.424**	-.435**
	Households assisted by livelihood protection	.295	.269
	Welfare expenditure for 0-17-year-old children	.219	.166
	Family nuclei households	.119	.066
	Dual-income households	-.071	-.076
School	People having completed up to elementary or junior high school only	.319*	.300*
	People having completed up to high school only	.179	.204
	People having completed up to junior colleges or equivalent	-.293	-.315*
	People having completed up to colleges and universities	-.415**	-.412**
	High school graduates going to further education	-.507**	-.506**
	School-age children who participated school-based FMR program	-.319*	-.325*
Community	Population	-.276	-.284
	Population of foreigners	-.370*	-.384**
	Convenience stores	.446**	.456**
	Food and drink stores	.377*	.345*
	Eating and drinking places	.315*	.257
	Dental clinics	-.288	-.301*

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

DMFT data was missing for three prefectures in 2011 due to the Great East Japan earthquake and tsunami on March 11, 2011

DMFT: Decayed (untreated), Missing, Filled (treated) Teeth

Since the correlation coefficients for DMFT and the initial 18 independent variables were similar in the sample of 47 and the sample of 44 (excluding three prefectures which had no DMFT data in 2011 due to Earthquake and Tsunami), it was decided that the multivariate models could include all 47 prefectures (Table 6). The number of missing teeth data in Niigata prefecture was missing only in 2010, and the reason was not explained. However, the treated teeth (filled teeth) were 0.6 and untreated teeth (decayed teeth) were 0.2, and DMFT was 0.8 in the prefecture in 2010. Also, the number of missing teeth in Niigata in 2011, 2012, and 2013 were all 0. Therefore, the missing number was estimated as 0 in this analysis. The average missing teeth during the four years was 0.002 per person and had no correlation with DMFT, D, and F.

Based on the result from Pearson's correlation, six independent variables all significantly correlated with DMFT. These included average income per person ($r = -0.440$), numbers of high school graduates going to further education per 100 graduates ($r = -0.506$), numbers of students participating school-based fluoride mouth rinsing programs per 100 students ($r = -0.325$), population of foreigners per 100,000 persons ($r = -0.384$), and numbers of dental clinics per 100,000 persons ($r = 0.456$), and numbers of convenient stores per 100,000 persons ($r = -0.301$).

The multicollinearity among the six variables was analyzed. A review of the scatter plots (Figure 4) and correlation matrix (Table 7), suggests a close relationship between income, education, foreigners, dental clinics, and convenience stores. Tolerance values (Table 8) suggest that the income, education, and foreigner variables are not independent of each other (Table 8).

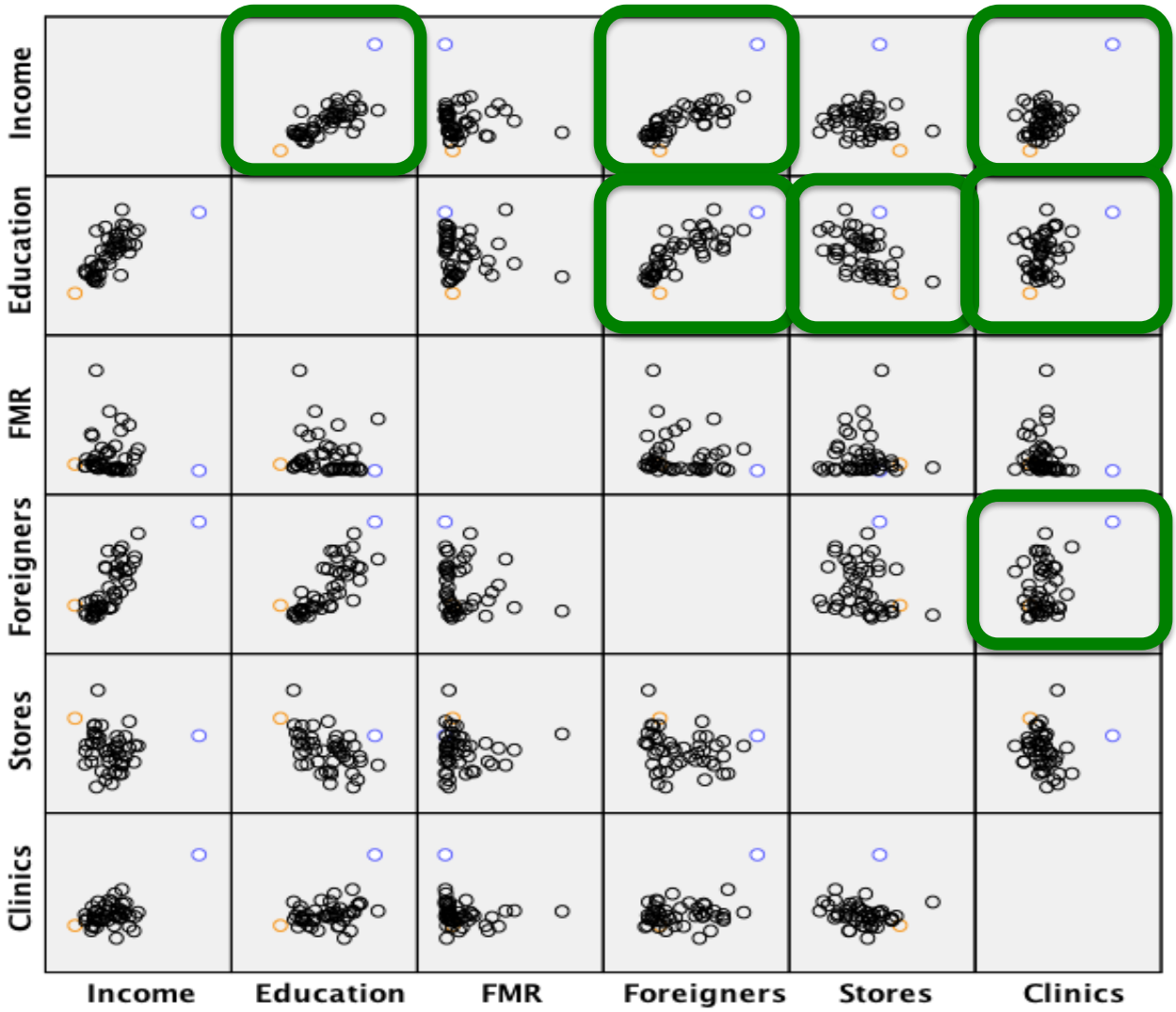


Figure 4. Scatter plot matrix of independent variables

Blue dot: Tokyo / Orange dot: Okinawa (Two colored prefectures seems to be outlier)

Green box: significantly correlated

Table 7. Correlation between independent variables

Domain		Income	Education	FMR	Foreigners	Stores
Family	Income					
School	Education	.726**				
	FMR	-.072	-.141			
Community	Foreigners	.787**	.789**	-.165		
	Stores	-.096	-.472**	-.021	-.188	
	Clinics	.560**	.392**	-.157	.346*	-.103

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Even though the variance inflation factor (VIF) for six variables are less than 10 (Table 8), such correlation suggests that prefectures with higher average income per person seem to have more opportunities for children to have higher level of education. Also, it makes sense that foreigners tend to live in prefectures where average income is high because there are more opportunities to work. Since it is not easy for foreigners to live in Japan (Jung, 2004), they may have more difficulty blending into rural area in Japan because of language and cultural barriers. Therefore, the income variable was chosen for a regression model, and the education and foreigners' variables were excluded.

Table 8. Tolerance values

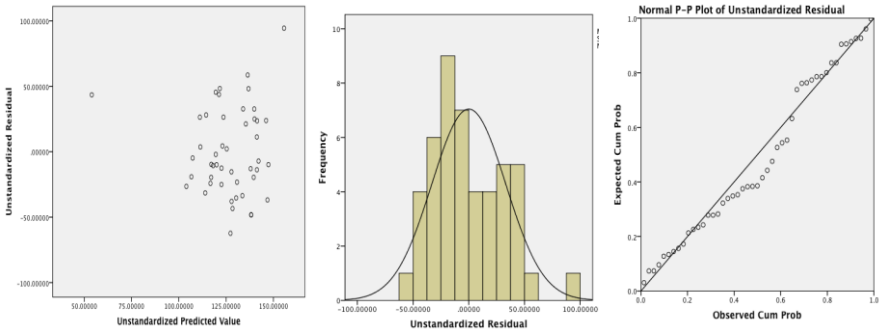
Six variables	p-value	Tolerance	VIF
Income	.379	.242	4.127
Education	.465	.227	4.408
FMR	.002	.918	1.089
Foreigners	.830	.257	3.885
Stores	.027	.619	1.616
Clinics	.351	.634	1.576
Three variables	**p-value**	**Tolerance**	**VIF**
Income	.000	.985	1.015
FMR	.003	.994	1.006
Stores	.001	.990	1.010

There is a significant correlation between dental clinics and the income variable ($r=0.560$, $p<0.001$) and between dental clinics and education variable ($r=0.392$,

p=0.006). This may mean that people in areas with more dental clinics tend to have higher education and income. It makes sense that the numbers of dental cavities for 12-year-old children tend to be fewer in such environments. In fact, though it is not statistically significant, the number of decayed teeth and dental clinics are also negatively correlated (r=-0.255, p=0.084). Therefore, even though the tolerance of dental clinics (0.634) was at an acceptable level, the dental clinic variable also was excluded to avoid confounding bias. Thus, in the initial regression equation, three variables—income, FMR participation, and convenience stores—were used as predictor variables. In the three variables model, all tolerances are higher than 0.98, and all VIF are about 1.0.

In addition, the three variables were examined for normality of error distribution. A review of the scatter plots of the errors across predicted values revealed no unusual pattern (Figure 4). Even though the P-P plot seemed to show a curvilinear relationship partially, evaluation of normality of error distribution and the Kolmogorov-Smirnov Test indicated that the errors were normally distributed. Therefore, the three independent valuables were retained in the regression model.

DMFT vs. Income



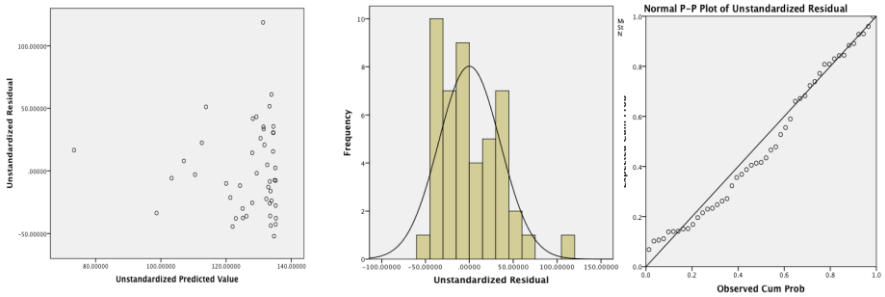
Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Unstandardized Residual is normal with mean -0.000 and standard deviation 33.28.	One-Sample Kolmogorov-Smirnov Test	.065[1]	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1]Lilliefors Corrected

DMFT vs. FMR



Hypothesis Test Summary

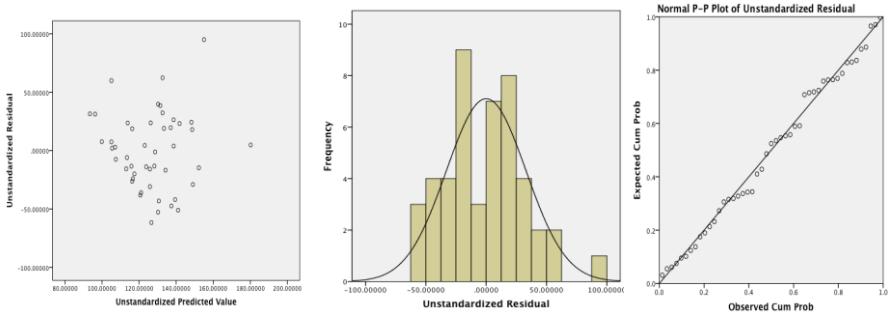
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Unstandardized Residual is normal with mean 0.000 and standard deviation 35.05.	One-Sample Kolmogorov-Smirnov Test	.200[1,2]	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1]Lilliefors Corrected

[2]This is a lower bound of the true significance.

DMFT vs. Convenient stores



Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Unstandardized Residual is normal with mean 0.000 and standard deviation 32.98.	One-Sample Kolmogorov-Smirnov Test	.200[1,2]	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1]Lilliefors Corrected

[2]This is a lower bound of the true significance.

Figure 5. Normality of error distribution

Results of the multivariate analysis are shown in Table 9. Using different combinations of variables, seven regression models were estimated to find the most predictive model.

Table 9. Model comparison

#	R^2	Regression Model
1	.194	Y'(DMFT) = 242301.785 – 42.645 × (Income)
2	.105	Y'(DMFT) = 135287.457 – 984.303 × (FMR)
3	.208	Y'(DMFT) = 31533.601 ＋ 3996.563 × (Convenience stores)
4	.321	Y'(DMFT) = 258574.633 – 45.160 × (Income) - 1086.577 × (FMR)
5	.366	Y'(DMFT) = 144589.992 – 38.745 × (Income) ＋ 3658.797 × (Convenience stores)
6	.307	Y'(DMFT) = 41233.174 – 955.714 × (FMR) ＋ 3938.588 × (Convenience stores)
7	.486	**Y'(DMFT) = 162634.506 – 41.271 ×(Income) - 1051.834 × (FMR) + 3572.974 × (Convenience stores)**

The most predictive model was #7. Specifically, almost 49% of the variance of the average numbers of DMFT of 12-year-old children is accounted for by the average income per person, the average numbers of convenience stores per 100,000 persons, and the average numbers of school-age children who participate school-based FMR programs per 100 students in respective prefectures. About 20% was explained by average income per person; about 10% was explained by FMR participation rate; and about 20% was explained by number of convenience stores (Table 9, Figure 6). However, the other 51% of the variance in DMFT could not be explained by this regression model.

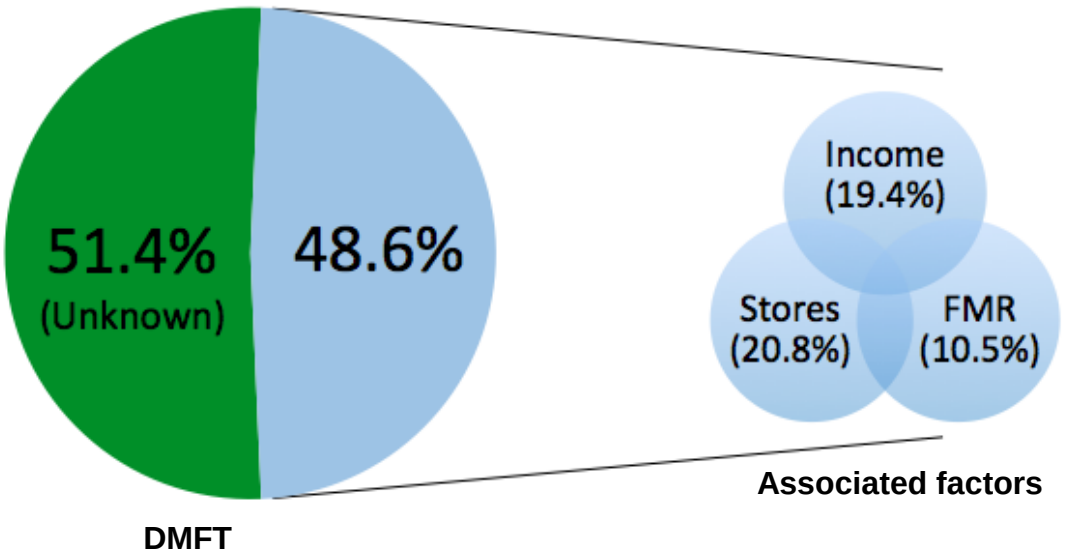


Figure 6. Percentage of prediction by the regression model

Table 10. Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	162634.506	39174.671		4.152	.000			
	Income2	-41.271	10.676	-.426	-3.866	.000	-.440	-.508	-.423
	FMR	-1051.834	332.510	-.347	-3.163	.003	-.325	-.434	-.346
	Stores	3572.974	963.197	.408	3.709	.001	.456	.492	.406

a. Dependent Variable: DMFT

The semipartial correlation between DMFT and income controlling for FMR participation and convenience stores was -0.423. This means that 17.9% of variance of the average number of DMFT of 12-year-old children is accounted for by income variable after controlling for FMR participation and convenience stores. Also, 12.0% of variance of DMFT was accounted for by FMR participation after controlling for income and convenience stores (semipartial correlations=-0.346). Since the zero-order correlation between DMFT and FMR participation (-0.325) is smaller than the semipartial correlation (-0.346), there seems to be a confounding effect between the three variables. Convenience store variable after controlling other two variables can account for 16.5% of DMFT variance (semipartial correlations= 0.406).

Regression diagnostics also were conducted to see if there were outliers that should removed from the analysis. The criterion for a large leverage value is a value greater than 2p/n, or 2(4)/47, which is 0.170. A review of the leverage values reveals three questionable prefectures—Tokyo, Saga, and Hokkaido—with leverage values of 0.466, 0.448, and 0.226 respectively (Table 11).

The criteria for identifying a possible outlier based on Studentized residuals (SR) and Studentized deleted residual (SDR) is a value exceeding 3, but there were no SR or SDR exceeding 3 (Table 11).

The criterion for a Cook's Distance is a value exceeding 4/n, or 4/47, which is 0.085. Another suggested cutoff for Cook's Distance is any value exceeding 1. A review of the Cook's Distance values suggests that Okinawa, with a Cook's Distance of 0.275, exceeded the cutoff of 0.085, but no prefecture exceeded the cutoff value of 1 (Table 11).

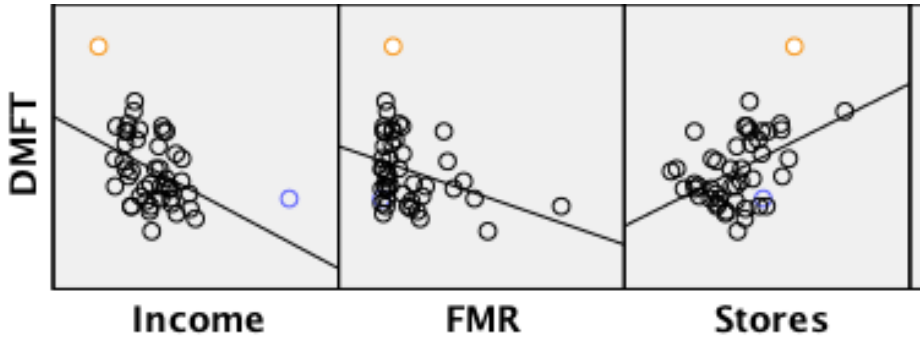
The criterion for a DFFITS value is larger than $2\times\sqrt{p/n}$, or $2\times\sqrt{4/47}$, which is 0.085. Among 47 prefectures, 24 prefectures exceed the suggested upper limit of DMFFITS of 0.085. However, Tokyo exceeded the cutoff most with a value of 19593.760, followed by Okinawa with 10947.735 and Mie with 4123.342 (Table 11).

Table 11. Variables and regression diagnostics

Prefectures	DMFT (n=47)	Income	FMR	Store	SR	SDR	Cook's Distance	Leverage	DFFITS
Hokkaido	185000	2473.00	2.00	37.20	-0.27	-0.26	0.01	0.23	-2091.57
Aomori	152500	2369.33	3.60	25.50	0.01	0.01	0	0.02	15.56
Iwate	120000	2408.67	2.40	29.40	-1.73	-1.77	0.06	0.05	-3714.65
Miyagi	166666	2540.00	3.90	29.30	0.31	0.31	0.00	0.04	560.09
Akita	165000	2366.67	21.80	25.30	1.22	1.23	0.03	0.04	2184.10
Yamagata	90000	2441.00	9.20	26.50	-2.11	-2.20	0.05	0.02	-2315.56
Fukushima	156666	2505.67	4.80	26.40	0.30	0.30	0.00	0.02	313.08
Ibaraki	137500	3075.33	0.20	30.20	-0.23	-0.22	0.00	0.08	-691.15
Tochigi	142500	2998.33	7.40	26.80	0.58	0.58	0.00	0.03	769.68
Gunma	117500	2878.67	1.70	25.70	-0.61	-0.60	0.00	0.02	-625.18
Saitama	97500	2808.33	1.80	21.50	-0.90	-0.89	0.01	0.01	-891.68
Chiba	110000	2869.00	1.40	23.10	-0.57	-0.56	0.00	0.01	-514.05

Tokyo	97500	4415.67	0.00	27.00	1.05	1.05	0.26	0.47	19593.76
Kanagawa	92500	2945.00	0.10	21.30	-0.92	-0.91	0.01	0.02	-1178.27
Niigata	65000	2696.00	37.20	23.80	-1.27	-1.28	0.07	0.12	-5248.41
Toyama	115000	3070.00	28.70	24.20	0.88	0.87	0.02	0.08	2676.62
Ishikawa	150000	2783.33	0.90	23.70	0.68	0.68	0.00	0.01	584.29
Fukui	170000	2828.33	0.80	24.70	1.36	1.37	0.02	0.01	1249.35
Yamanashi	165000	2838.67	0.80	26.80	0.92	0.91	0.01	0.02	1121.26
Nagano	95000	2626.33	10.40	23.60	-1.20	-1.21	0.01	0.00	-759.86
Gifu	85000	2670.67	12.50	22.40	-1.26	-1.27	0.01	0.00	-915.79
Shizuoka	87500	3181.00	10.30	24.80	-0.81	-0.81	0.01	0.04	-1333.35
Aichi	77500	3243.33	13.50	24.70	-0.96	-0.96	0.02	0.05	-1954.52
Mie	165000	2878.67	0.90	18.40	2.12	2.22	0.08	0.05	4123.34
Shiga	102500	3165.00	7.40	21.10	0.11	0.11	0.00	0.04	177.92
Kyoto	97500	2936.00	32.50	20.40	0.67	0.67	0.02	0.10	2497.70
Osaka	107500	2934.67	0.10	18.50	-0.00	-0.00	0	0.05	-1.01
Hyogo	107500	2615.67	1.90	17.10	-0.24	-0.24	0.00	0.07	-606.75
Nara	125000	2446.33	1.90	15.50	0.39	0.38	0.01	0.11	1512.54
Wakayama	112500	2684.00	11.20	18.40	0.25	0.25	0.00	0.04	413.54
Tottori	110000	2238.00	3.00	23.60	-1.56	-1.58	0.04	0.04	-2736.88
Shimane	135000	2348.67	23.10	21.20	0.68	0.67	0.01	0.06	1504.15
Okayama	90000	2682.67	1.60	21.20	-1.33	-1.35	0.02	0.02	-1420.05
Hiroshima	82500	3009.33	0.60	22.30	-1.30	-1.31	0.02	0.02	-1632.56
Yamaguchi	107500	2912.00	25.20	20.50	0.69	0.69	0.01	0.06	1591.86
Tokushima	127500	2743.00	0.10	16.20	0.78	0.78	0.02	0.08	2361.55
Kagawa	110000	2808.00	15.50	18.90	0.45	0.45	0.00	0.04	734.56
Ehime	100000	2549.33	14.20	19.00	-0.39	-0.39	0.00	0.04	-649.44
Kochi	137500	2226.33	2.70	20.60	-0.15	-0.15	0.00	0.06	-355.21
Fukuoka	127500	2796.00	0.40	24.30	-0.23	-0.22	0.00	0.01	-204.93
Saga	90000	2439.33	62.90	27.40	-0.18	-0.18	0.01	0.45	-3278.20
Nagasaki	127500	2368.67	6.00	22.90	-0.48	-0.47	0.00	0.02	-572.59
Kumamoto	172500	2401.67	6.10	29.20	0.42	0.41	0.00	0.05	807.93
Oita	195000	2482.67	1.40	25.30	1.70	1.74	0.03	0.02	1893.44
Miyazaki	170000	2255.00	7.20	25.00	0.70	0.69	0.01	0.03	1058.13
Kagoshima	165000	2398.67	3.80	27.60	0.25	0.25	0.00	0.03	388.76
Okinawa	250000	2032.67	4.00	30.90	2.56	2.75	0.28	0.12	10947.73

Based on the diagnostic results using leverage values, SR, SDR, Cook's Distance, and DFFITS, there was no prefecture exceeding all diagnostic criteria. However, a visual inspection of the scatter plot (Figure 7) of DMFT and three variables suggests that Okinawa may be a significant outlier that would impact the regression equation.



Blue dot: Tokyo

Orange dot: Okinawa

(Okinawa seems to be an outlier)

Figure 7. Outlier analysis

However, once the outlier (Okinawa) was removed, the over all R^2 value decreased from 0.486 (n=47) to 0.422 (n=46 without Okinawa) (Table 12). The beta values decreased for all three predictors as well (Table 12). In addition, all variables were statistically significant and the overal outcomes were similar in models with and without Okinawa. Thus, Okinawa was retained in this analysis.

Table 12. Regression models with and without Okinawa

	R^2	p-value	Regression Model
n=47 (With Okinawa)	.486	.000	Y'(DMFT) = 162634.506 - 41.271×(Income) – 1051.834×(FMR)+3572.974×(Convenience stores)
n=46 (Without Okinawa)	.422	.000	Y'(DMFT) = 155011.743 – 34.093×(Income) – 987.828×(FMR)+2984.898×(Convenience stores)

Although there were other prefectures with one or two elevated values, all of the statistics together, combined with a visual inspection of the scatter plots, suggest that none of the prefectures needed to be removed from this analysis.

The overall model for predicting the numbers of average DMFT per 100,000 12-year-old children in Japan is as follows: Y'(DMFT) = 162634.506 – 41.271*(Income) – 1051.834* (FMR) + 3572.974*(Convenience stores). This model was statistically significant (F=13.547, p<0.001) and explained 48.6% of the variance in the numbers of average DMFT per 100,000 12-year-old children. The beta value for Income (1000 yen) per person per year is -41.271. This value is statistically significant (t=-3.866, p<0.001). The beta value for the numbers of children who participates FMR programs at schools per 100 children is -1051.834. This value is also statistically significant (t=-3.163, p=0.003). And the beta value for the numbers of convenience stores per 100,000 persons is 3572.974. This value is also statistically significant (t=3.709, p=0.001).

This means that an increase in average income by one standard deviation (SD=382, 382,404 yen = about $4,000) is associated with a decrease of 41 DMFT per 100,000 12-year-old children. Increasing FMR participation by one standard deviation (12.22%) is associated with a decrease of 1,052 DMFT per 100,000 12-year-old children. Increasing the number of convenience stores per 100,000 persons by one standard deviation (4.23) is associated with an increase of 3,573 DMFT per 100,000 12-year-old children.

Discussion

The most predictive and parsimonious model based on this analysis included three variables—mean income per person for the prefecture (representing the family level), percent of students participation in school-based FMR in the prefecture (representing the school level), and convenience stores per 100,000 population in the prefeture (representing the community level). This model explained approximately 49% of the variance of the average numbers of DMFT of 12-year-old children.

It is not surprising that mean income is strongly associated with DMFT of 12-year-old children by prefecture. Previous nationwide research in the United States also showed family income as predictor of child cavities (Data Resource Center for Child & Adolescent Health, 2007). Even though Japan has universal health insurance coverage system and treatment of cavities for children from low-income families are free, the

income variable shows similar result to previous research in the United States. The findings also suggest that increasing average income may reduce DMFT of 12-year-old childen. To increase income, Japanese government provides financial supports to low-income groups. These supports include livelihood subsidies (*Seikatsu hogo*), child allowance (*Jido teate*), and special welfare benefits (*Fukushi kyufu kin*). Due to increases in the number of low-income individuals in Japan over the past decade, especially older adults who have limited pensions, both individual and household receipients of government benefits have increased (Ministry of Health, Labor and Welfare, 2015b). To provide adequate social welfare, Japanese government has required increases in tax income. For example, the consumption tax was introduced in Japan in 1989. It was raised from 3% to 5% in 1997 and to 8% in 2014, and it is scheduled to be increased to 10% in 2017. Such increases of tax rate have increase financial burden for all citizens in Japan. It remains to be seen if these tax increases will help increase income enough to reduce DMFT among children.

Second, the number of convenience stores per 100,000 persons also can predect DMFT of 12-year-old children. The relationship between convenience stores and DMFT has not described in previous research related to child cavities. However, a previous study showed that environmental factors, such as high concentration of fast food outlets, are associated with health outcome such as obesity (Mau et al., 2008). In Japan, the industry of convenience stores has been successful, and total amount of sales at the convenience stores exceeded 10,000,000,000,000 yen (about $82 billions) in 2014 (Japan Economic Newspaper (*Nihon Keizai Shimbun*), 2015). Since the total amount of sales at the convenience stores has been increasing, it is an important social factor to consider. The findings suggest that reducing the number of convenience stores per 100,000 persons may reduce DMFT of 12-year-old childen. However, closing convenience stores may reduce income of owners, thereby affecting income. It also might decrease municipal tax revenue, which might decrease money allocated to schools to implement school-based interventions. So reducing convenience stores may not be the best approach to decreasing DMFT among children. Alternatively, reducing the number of sugared beverages or sugary snacks or increasing healthy food options

at convenience stores may effect on the relationship with DMFT of 12-year-old children. However, stores may resist efforts to enact policy to reduce sales of sugary options at convenience stores because of fear that this would decrease sales.

Finally, the findings suggest that increasing child participation in school-based FMR programs may reduce DMFT. Based on the results from previous research, FMR programs have been shown to be very effective as reducing DMFT in school children in Japan (Yasuda, 2014). This approach also has been promoted as a safe and effective way to reduce cavities in the United States, especially in communities that do not have fluoridated water (Association of State and Territorial Dental Directors, 2011; Centers for Disease Control and Prevention, 2001; Commonwealth of Massachusetts, Department of Public Health, n/a; Divaris, Rozier, & King, 2012; Rugg-Gunn & Bánóczy, 2013; U.S. Food and Drug Administration, 2015).

Of the three significant variables, increasing access to FMR programs is the best option for intervention. However, expanding the FMR intervention has faced social barriers in Japan due to oppositions by citizens groups towards fluoridation and use of fluoride in schools (Cunsumers Union of Japan, 2014; Japan Federation of Bar Associations, 2011). Despite abundant international evidence about the benefits of tap-water fluoridation and FMR use in schools, several vocal groups in Japan are worried about potential side effects from fluoride use. They also claim the human right to choose their own way of prevention, rather than being forced into having their children join such school-based prevention program. However, they do not suggest alternative ways to provide public intervention programs to reach all children, including those from low-income families and those with limited dental resources. Since the majority of Japanese have difficulty accessing information written in languages other than Japanese or understanding academic findings from evidence-based research, governmental leadership must take more responsibility to explain the safety of FMR program to the public and more vigorously urge increased participation in such programs.

Limitation

While this study has significant strengths using reliable nationwide governmental data, it also had some limitations. One limitation was the sample size (n=47). Since the numbers of prefectures was small, only a few predictive variables were selected in the final model. A transparent and standard process was used to reduce the numbers of possible independent variables. However, if there were a larger sample size and more varieties of data, other methods for variable selection, such as the Principle Components Analysis, could be utilized instead of using correlation.

A second limitation reflects limitations inherent in secondary data analysis, i.e., we had a limited number and type of variables to consider, and each was collected according to a preset timetable. For example, there was no information about sugar consumption by prefectures, even though it is a key dietary habit that impacts cavities. If all variables were collected every year, associations could be estimated between variables collected every year rather than using multi-year averages. In addition, since only published datasets were used, correlations between variables were revealed, but causal association could not be revealed. One solution may be conducting a longitudinal study instead of using cross-sectional data. However, the longitudinal study also has several disadvantages. For example, it takes a long time to gather results, a large sample size is needed, accurate sampling is necessary to reach representativeness, and participants may drop out (subject attrition).

A third limitation is bias. Since datasets from various resources were used, all data were based on different individuals. Even though only nationwide datasets published by the Japanese government, except data about school-based FMR programs, were used as reliable resources, each dataset may have some fluctuations due to sampling error.

Conclusion

From this analysis, three prefecture-level variables were the most predictive factors of DMFT for 12-year-old children in Japan: Average income per person, numbers of school-age children (from preschool to junior-high school) who participated

in school-based FMR program per 100 students, and numbers of convenience stores per 100,000 persons.

Among the three variables, increasing participation rate for FMR seems to be the most feasible and cost-effective way to reduce DMFT of 12-year-old children in Japan, which has rejected general fluoridation of the water supply. Therefore, it is necessary to advocate for the importance of providing cavity prevention programs, such as school-based FMR in a way that community members without an academic background can understand to combat mistrust of this program that appears to arise from lack of information or misinformation about these programs.

CHAPTER 4

Abstract

The purpose of this student was to better understand the barriers and facilitating factors to prevent cavities of children of Japanese nationals in Hawai‘i. Eleven semi-structured qualitative interviews were conducted with Japanese nationals who were parents of elementary-school-age children living in Hawai‘i. Data about their children’s dental health care and prevention were collected and coded using the framework method. The main barriers were uninsured status, slow adaptation to U.S. oral health system by Japanese mothers, and Japanese hesitancy to ask questions. The main facilitating factors were having oral health insurance coverage (either through QUEST or private insurance), high cost for insurance and treatment, and the U.S. check-up appointment system. Parents who have lived outside of Japan for less than five years were less likely to know about cavity prevention methods to promote cavity prevention in their children, and less likely to know the importance of having oral health insurance for their children in the U.S. To reduce the risk of child cavities, Japanese parents living outside of Japan for less than five years should have opportunities to learn about the major differences of dental health care systems between the U.S. and Japan to realize the oral health risks to their children in the U.S. Mandatory oral health care insurance would encourage parents to use oral health services for their children. Dentists must assure that Japanese parents understand and agree to follow cavity prevention recommendations, since many of them hesitant to speak out.

Introduction

The research question of this study is “What are the barriers and facilitating factors to prevent cavities in children of Japanese nationals living in Hawai‘i?” This question was addressed using qualitative methods.

Globalization is a reality, not a choice (Chen & Berlinguer, 2001). In the U.S., the foreign-born population, including anyone who is not a U.S. citizen at birth, has been increasing over the past 50 years (United States Census Bureau, 2013). Foreign-born women in the U.S. are more likely to have given birth than U.S.-born women (Grieco et

al., 2012). Thus, children of immigrants account for 22% of children under 6 in the U.S., while total immigrants account for only 11% of the total U.S. population (Capps, Fix, Ost, Reardon-Anderson, & Passel, 2005). It is estimated that almost 30% of all children in the U.S. will have at least one immigrant parent by 2020 (Capps et al., 2005).

In 2013, the foreign-born population rate was highest in California at 27.0%, followed by 22.1% in New York, 21.2% in New Jersey, 19.4% in Florida, 19.1% in Nevada, and 17.9% in Hawai‘i (U.S. Census Bureau, 2013). Since such diverse and changing family structure may influence the pattern of diseases and demands of prevention, it is important to study immigrant populations and their children.

Children of immigrants tend to have disadvantages in terms of untreated cavities compared to the U.S. average (Pollick et al., 1987). This is likely because children's oral health is influenced by parents' belief and behaviors (Castilho, Mialhe, Barbosa, & Puppin-Rontani, 2013; Duijster et al., 2013). Even when controlling for demographic factors, socio-economic status, and insurance, children of immigrant parents experience more health problems and less access to care than other children (Ziol-Guest & Kalil, 2012). Children whose caregivers prefer to use the home-country languages especially tend to have more cavities than those who prefer English (Maserejian, Trachtenberg, Hayes, & Tavares, 2008). In addition, previous research shows that immigrant mothers tend to have lower levels of caries-related knowledge and poorer attitudes and oral health behaviors than native-born mothers (Chen et al., 2014). The fact that the majority of immigrants do not have dental care insurance is also a serious issue that contributes to not using dental care services (Cruz et al., 2010). Language and cultural barriers are also important factors in accessing dental care services for Chinese immigrants in Canada (Dong, Levine, Loignon, & Bedos, 2011). Therefore, it is critical to provide culturally competent oral health services to immigrants and their children.

Japan also is becoming more globalized. The number of Japanese living outside of Japan has been increasing since 1968, the beginning of national tracking of this variable in Japan (Ministry of Foreign Affairs of Japan, 2015). The latest data show that there were at least 1,290,175 Japanese living abroad in 2014. Among those living outside of Japan, the highest numbers of Japanese are living in the U.S. (32% of

Japanese living abroad, 414,247 persons), followed by China (10%, 133,902 persons), and Australia (6.6%, 85,083 persons) in 2014.

The number of Japanese living abroad can be divided into long-term residents (temporary migrants) estimated at 853,687 (66%) and permanent residents estimated at 436,488 (34%). People, categorized as long-term residents, are those living in foreign countries temporarily who plan to return to their home country someday, such as international students. People categorized as permanent residents are those legally permitted to live in foreign countries permanently and who base their lives in these countries, such as green card holders by marriage with Americans in the U.S. These data do not include tourists, short-term residents living in foreign countries for less than three months, and U.S. citizens who are Japanese descendants.

The state of Hawai‘i has one of the highest Japanese populations in the U.S. As of October 1, 2014, the Consulate General of Japan in Honolulu reported 20,704 Japanese nationals living in Hawai‘i and American Samoa, including 14,390 categorized as permanent residents and 6,314 categorized as long-term residents. Among them, 3,540 Japanese (17%) are less than 20 years old (Ministry of Foreign Affairs of Japan, 2015).

Permanent residents can access many U.S. health care services, including supports for low-income families. For many long-term residents who are working or whose spouses are working full time, employers provide insurance for their children and certain amount of monthly income. However, there may be not enough health care services provided for foreign children of long-term residents with limited income.

For example, the Hawaii QUEST Program is a Medicaid managed care program supported by the State of Hawai‘i. Children in low-income families, as long as they were born in the U.S. or at least one parent is American, can be enrolled in the program. Dental check-up and basic treatments can be provided free of charge for those covered by QUEST (State of Hawai‘i, 2015). Legal residents with limited income can also enroll in Medicaid after five years, and children of legal residents can often enroll in CHIP or Medicaid without the five years waiting periods (Center for Medicaid and CHIP Services, 2014). However, most of foreigners who recently relocate from other countries are not

familiar with the system. Therefore, children of foreign parents may not be able to receive benefits from the existing health care systems in the U.S.

Hawai‘i water is not naturally fluoridated, nor has the state passed laws to fluoridate the drinking water (The Honolulu Advertiser, 2004) except in Army family housings following Army standards (U.S. Army-Hawaii, 2016). The state of Hawai‘i has the lowest rate (10.8%) of water fluoridation in the U.S. (Centers for Disease Control and Prevention, 2011), and the screening of more than 9,100 children by the Hawai‘i State Health Department in 2010 showed that 27% of them had serious dental problems that required “urgent or acute dental treatment” (American Academy of Pediatrics, 2012). Also, it is estimated that 100,000 (>50%) of 5-9 year old children in Hawai‘i have untreated dental decay, and this rate is almost twice of the national average (>29%) (Deguchi et al., 2013).

The Pew Trusts Oral Health Reports gave Hawai‘i an “F” grade for the state’s lack of programs or policies to prevent cavities (The PEW Charitable Trusts, 2013). In addition, immigrant children are at higher risk to develop more cavities, since they tend to have more untreated cavities than the U.S. average (Pollick et al., 1987) and access care less frequently than other non-immigrants (Ziol-Guest & Kalil, 2012). Language and cultural barriers (Dong et al., 2011) and lack of insurance enrollment (Cruz et al., 2010) are also related to the higher risk of oral health problems among immigrant children. The facts of many immigrants and limited programs to prevent cavities in Hawai‘i may be related to serious outcomes by previous research. However, there must be different problems between immigrants from different countries.

Therefore, the purpose of this study was to examine barriers and facilitating factors of Japanese national parents living in Hawai‘i in preventing cavities in their children. These data will help to illuminate and inform intervention development to reduce oral health issues among children of Japanese parents in Hawai‘i.

Methods

Participants

After one pilot interview in October 2014 to pretest the interview questions, nine interviews with ten participants were conducted from September to November 2015. In all, ten mothers and one father from ten families were interviewed, and recruitment was stopped upon reaching thematic saturation to collect information about barriers and facilitating factors to prevent child cavities. Nine interviewees out of eleven were those who were unknown to the interviewer (SY) before the interview, including one recruited through a web site advertisement.

At the beginning, participants were recruited through the researcher's friends by snowball sampling, as long as they fulfilled the following two inclusion criteria: 1) at least one parent or caregiver was from Japan and living in Hawai‘i, and 2) the child (or children) was attending elementary school in Hawai‘i. After conducting a few interviews, theoretical sampling was used to recruit Japanese national participants in various situations by adding the following inclusion criteria: 3) families living in Hawai‘i for less than three years, 4) families whose children did not have dental insurance in Hawai‘i, or 5) parents of children with dental problems.

Exclusion criteria were the following: 1) U.S. citizens of Japanese ancestry, 2) Japanese who are born or grew up mainly outside of Japan, 3) short-term (less than three months) residents and tourists, and 4) parents who are not involved in their child's care. The reason for the exclusion criteria 1) and 2) were to study Japanese steeped in Japanese culture but living in Hawai‘i. Short-term residents and tourists were excluded since they are based in Japan and would most likely receive all dental care in Japan. Parents who were not the main child caregivers were excluded to gain accurate information about the child and his/her care.

The length of time living in Hawai‘i was used as preferred inclusion criteria after few interviews. The reason is because long-term residents have more networks in Hawai‘i and many of the introduced Japanese as possible interviewees have lived in Hawai‘i more than half of their life. To focus on recent residents, Japanese mothers

living in Hawai‘i for more than three months and less than three years were intentionally recruited.

Measures

Interviews were conducted as face-to-face, semi-structured interviews. All interviews were conducted with individuals except one case. One interviewee kindly brought his wife and three children at the interview place to provide accurate information. While the parents were interviewed, the children were playing around, and occasionally came to show an oral health condition and treatment upon the request of their parents. Interviews were conducted at the location of the participants' preference, such as interviewee's home, interviewer's home, and open space in public.

At the beginning, the interviewer asked several basic recruitment questions before the interview. However, some potential interviewees seemed to worry that the interviewer might be seeking personal information for fraudulent purposes. Therefore, after several interviews only basic questions, such as name, contact number, nationality, and age of children, were asked to the rest of participants.

Procedures

The interviews lasted about one hour, including informed consent. The interviewer conducted the interviews in Japanese and audio-recorded them with the participants' permission. Before the interview, all participants were informed about the voluntary nature of the study and their rights to refuse to answer questions and to withdraw from the study at any time without penalty. They were asked to sign a consent form approved by the Social and Behavioral Sciences IRB at the University of Hawai‘i (CHS#22904). Four of the interviews also were observed by a Japanese master-level public health student serving as a research assistant, with the participants' permission. Audio recordings were transcribed in Japanese after the interviews.

Questions were asked in a number of areas related to family characteristics and child oral health care. Information about demographic characteristics of parents and families was asked at the beginning of interviews (Table 13). Even though most of

interviewees were mothers, they answered questions about fathers and children too. Questions evolved over the course of the interviews to explore new ideas stimulated by previous interviews. These items are noted with an asterisk (Table 13).

At the beginning, the interviewer did not ask detailed question about absent (separated or divorced) spouses, since such questions might be too sensitive. However, this seemed to be an important factor in the provision of adequate oral health support for children from the perspective of insurance, amount of support, household income, and mental health status of parents and child. Thus, detailed questions were added, such as “How has your life changed because of the divorce?” “How did the divorce affect the oral health insurance for children?” “How has your husband living separately supported you financially?” and “How much time do children spend with your ex-husband?”

All answers were provided verbally except household income and English level. For the two questions, interviewees pointed out an appropriate category on the list created by the interviewer. The question of family income was supposed to ask yield information on total household income. However, some families, such as temporarily separated, separated, and divorced families, did not know the spouse’s or ex-husband’s current income. Therefore, regardless of marital status, the household income used for children was asked instead.

The way to ask family income was also modified. At the first interview, a list income by the number of family members for 100% of Federal Poverty Line (FPL) was showed, and the interviewee was asked if their family income is below or above. However, the interviewer realized this approach might be considered impolite. Therefore, a modified list was shown consisting of five FPL price range between 0-49%, 50-99%, 100-150%, 150-199%, over 200% without explanation of FPL. In addition, equivalent Japanese currency (Yen) was calculated for those who have income only in Japanese currency and do not know how much it was in U.S. dollars.

Table 13. Questions asked to participants

Areas of questions	
Information about family structure	• Numbers of family members living together • Reason of family members living separately* • Resource and amount of family income * • Support for child care
Information about all family members	• Age, gender, and nationality • Length of time living in Hawai‘i and outside of home countries • Language level (English, Japanese, other when needed)* • Frequency of going back to Japan and time spent there • Visa status and reason for living in Hawai‘i
Information about parents	• Marital status and relationship of parents* • Shares of contribution about childcare between mothers and fathers* • Academic background • Working status • Resource of information*
General concern about child (children)	• Things that concern parents most about the child • Use of public resources for health care or social welfare • Behavior of seeking help when needed
Oral health of child (children)	• Oral health insurance (U.S. and Japan)* • Frequency of and reason for visiting dentists • Cost and burden of dental care • Satisfaction with dental care in Hawai‘i and in comparison to Japan • Concerns about oral health of child • History of cavities • Methods to prevent cavities at home • Action to take when parents realize new cavities of child • Barriers to provide oral health care for children • Future effect of cavities • Motivation to provide oral care for children (parents/children) • Opportunities to learn about oral health
Living in Hawai‘I	• Good parts of living in Hawai‘I • Hardships of living in Hawai‘i • Relationship with other Japanese*
Follow up	• Questions that were unclear or difficult to answer • Questions from interviewees • Additional comments or change of previous response • Possibility to ask additional questions later

Even though all interviewed mothers were from Japan and were Japanese nationals, some fathers had different situations. To calculate father's length of life outside of home countries, countries at birth were used as home countries regardless of their current nationalities. For example, Japan was considered as a home country for Korean fathers who were born and raised in Japan, and Taiwan was considered as a home country for an American father who moved to the U.S. from Taiwan at age 15.

Interviews were conducted only in Japanese, and interviewees were asked to estimate their level of English fluency. Since Japanese tended to underestimate their own abilities due to the importance of modesty in Japanese culture, the interviewer asked their scores from 0 to 10 (0 as no English knowledge, 5 as no problem for daily life in English speaking countries, and 10 as the level of native English speakers).

Contribution to childcare by mothers and fathers and related question were asked to examine how much of the childcare burden, including burden to provide oral health care, was carried by the mother. For example, questions such as "What percentage of total childcare do you provide?" and "What kind of childcare does your husband provide?" were asked. Such questions easily let interviewees express their opinions, including complaints, about their partners. However, estimated contributions to childcare were subjective, and estimates by the other parent could be different.

In addition, since many interviewees mentioned other mothers as primary resources of information, related questions were added, such as "Is there any stress or difficulty in your relationships with Japanese mothers?" and, if relevant, "Why did you decide not to provide supplemental education for children at Japanese schools?" and "Why don't you like having close relationships with other Japanese?"

Basic questions about oral health insurance asked, such as name of insurance company, coverage, and price. Additional questions were added to search reasons of behaviors, including "Who chose the insurance?" "Why did you choose it?" and "Was there any other option?" Those who changed insurance status were asked about reasons for the change and behaviors before and after the change.

Since all interviewees agreed that the interviewer could contact them for additional questions, participants were contacted later by email to answer the more detailed questions that evolved over the course of the study and to clarify their answers.

Analysis

The framework method (Gale et al., 2013; Pope et al., 2000) was conducted to analyze qualitative data systematically with the following four steps—familiarization, coding, charting, and interpretation.

The first step is familiarization. Even though all interviews were conducted by the researcher (SY), all of audio recording were listened to, transcripts were read, and field notes were studied several times by the interviewer to become immersed in the data.

The second step is coding. A combined deductive and inductive approach was used to produce the codes, which are descriptive or conceptual labels of the data. In the deductive approach, themes and codes were pre-selected based on previous research (Castilho et al., 2013; C.-C. Chen et al., 2014; Cruz et al., 2010; Dong et al., 2011; Duijster et al., 2013; Maserejian et al., 2008; Pollick et al., 1987; Ziol-Guest & Kalil, 2012). Even though the aim of this study was to explore the barriers and facilitating factors to prevent cavities in children and themes and codes were pre-selected, space was left to discover unexpected aspects of the oral health issue of children. Therefore, in the inductive approach, additional themes were generated from the data through open coding. To involve different perspectives and to ensure reliability, a Japanese graduate student who observed four interviews and a Japanese dentist working in Hawai‘i provided their opinions about codes.

The third step is charting, in which the data were rearranged according to the appropriate part of the thematic framework and related code. Then, the data were further divided into barriers and facilitating factors for preventing child cavities.

In the fourth step, interpretation, the range and nature of phenomena were interpreted using charts to define concepts. Typologies (categories of codes) were created and associations between themes were found to provide explanations for the

findings. The common comments and adverse comments were written in narrative form in the result section.

Results

Participant demographics

Through the interviews, information about all family members was gathered, as well as information about dental health of children. Table 14 summarizes parents' demographic characteristics, and Table 15 summarizes brief family information. Even though ten mothers and one father from ten families were interviewed, information about the rest of fathers was gathered through interviewed mothers.

Among interviewed families, time living in the U.S. of parents varied from 6 months to 33 years. Fathers tended to have more education than mothers, and all had full-time jobs but one participant who was a high school graduate and unemployed. Half of mothers, including one graduate student, did not work outside the home, but all of the participants said their household income was more than 200% of FPL. The divorced single-mother families and a family with several children said their household income was almost 100% of FPL or between 100-150%. No family was living below 100% of FPL.

All of the mothers interviewed were Japanese. According to the mothers, the two Korean fathers were born and raised in Japan and spoke only Japanese, and one American father was an immigrant from Taiwan at age of 15.

Four out of ten pairs of parents were married and living together at the time of interviews. Three married couples were living separately, with the fathers working in Japan and the mothers staying in the U.S. Another married couple was living separately in Hawai‘i because their relationship was not good. Two sets of parents were divorced, but both parents were living in Hawai‘i.

Table 14. Demographic characteristics of parents (n=20) as reported by participants (n=11)

		Mother	Father
Age		ave 40.0 (33 - 47)	ave 44.3 (34 – 59)
Years in Hawai‘i		ave 7.1 (1.5 – 22)	ave 9.3 (0.5 – 32.5)
Years out of home countries (including years in Hawai‘i)		ave 11.3 (1.5 - 22)	ave 6.9 (0 – 29)
English level	0: No knowledge 5: No problem for daily life 10: Native speaker	ave 5.3 (1 – 8)	ave 7.8 (1 - 10)
Nationality	Japanese American Korean	10 0 0	3 5 2
Education	High school Vocational school College Undergraduate Master PhD	2 1 2 2 3 0	1 0 0 4 4 1
Work	Unemployed Employed	5 5	1 9
Rate of childcare		ave 79% (50 - 100%)	ave 21% (0 – 50%)

Three of the ten mothers had one child, and the other seven had two or more children. Mothers reported providing an estimated 79% of childcare, and reported that fathers provided around 21% of childcare. This rate was estimated by interviewed mothers objectively considering the total amount of childcare. Among the six mothers in families without fathers, divorced mothers tended to answer more positively than temporarily separated mothers about the burden of childcare. Temporarily separated parents tended to mention the burden to be a single parent at home, whereas divorced women seemed to be fine with independently providing childcare without seeking help from the ex-husband.

No families used English only at home. All used Japanese, or a combination of Japanese and English (and Chinese in the family with the father from Taiwan). Mothers rated the English-language proficiency of fathers higher than they rated their own (mean

7.8 out of 10 for fathers, vs. 5.3 out of 10 for mothers). Nine of ten mothers said they have returned to Japan with their children at least once a year.

Table 15. Demographic characteristics of families (n=10 families)

		# of family
Parent's marital status	Married (live together) Temporarily separated[a)] Separated[b)] Divorced	4 3 1 2
Household income	100-149% of FPL[c)] 150%-199% of FPL Over 200% of FPL	3 2 5
# of children	One Two Three	3 5 2
Language used at home	English only Japanese only English and Japanese English, Japanese, and Chinese	0 4 5 1
Frequency to go back Japan	Less than once / year Once / year Twice / year	1 6 3

a) Temporally separated = parents live separately since fathers are working in Japan.
b) Separated = parents live separately in Hawaii since their relationship is not good.
c) FPL = Federal Poverty Line

Since the sample size of this study is very small (n=11) and they were recruited by snowball and theoretical sampling, they may not represent the target populations. However there seems to be some trends among interviewees.

Oral Health insurance

During the recruitment process and first few interviews, the interviewer realized that many Japanese families living in Hawai'i seemed to have dental insurance for children. Therefore, uninsured families and those insured by QUEST were intentionally recruited to compare the difference of behavior and beliefs (Table 16). One family recently enrolled in oral health insurance for children after three years of living in Hawai'i while the mother completed school. Two families had only Japanese tourist insurance

without oral health coverage. Since there is no co-pay system for Japanese tourist insurance (all treatment is covered up to a set limit), some Japanese prefer to use such Japanese tourist insurance over U.S. insurance in U.S. One family recently cancelled their U.S. oral health insurance after one year of living in Hawai‘i and mentioned that they were not qualified to re-enroll for at least for two years due to the insurance policy. Children in two out of the three uninsured families had more cavities than those in insured families. One of the three families had spent thousands of dollars to treat a child’s cavities in Hawai‘i last year, and the other two families said they will wait to go back to Japan next time for treatment since they are still covered by a dental health insurance in Japan.

Mothers of three uninsured families had less experience living outside of Japan (average length was two years). A mother lived outside of Japan for 4.5 years, including 3.5 years in Hawai‘i, recently enrolled in oral health insurance. Six mothers who had lived outside of Japan longer than 5.0 years were more likely to have oral health insurance for their children compared to mothers with less living experience outside of Japan. However, fathers’ length of life outside of home countries seemed to have no association with child’s oral health insurance status. In addition, there was no family without medical health insurance.

Cavities of children

In four out of ten families, children had never developed cavities (Table 16). In three families, children developed a small numbers of cavities in the past. The tendency of developing cavities varied between siblings. However, interviewees reported that many cavities developed when parents were busy, such as when moving internationally, taking care of several young children, or divorcing. In three families, children developed cavities frequently. Two of these three families were uninsured and did not use any preventive services except tooth brushing. The other family was covered by QUEST and took children for check-ups every six months, and these children were using dental floss.

Frequency of brushing teeth

Four families brushed their teeth once a day at night, and six families brushed their teeth twice a day at morning and night (Table 16). The frequency of brushing was depending on families' custom instead of individual children's custom. Some parents brushed their children's teeth again after the children brushed by themselves. In addition of brushing teeth, seven families provided other prevention of cavities, such as flossing, sealant, fluoridation by application or pills, or toothpaste with fluoride. The parents provided such prevention methods mainly based on dentists' recommendations. All seven of these families providing prevention methods had lived in the U.S. more than four years.

Dental check-up

The three families going back to Japan twice a year reported visiting the dentist mainly in Japan; one of these families was uninsured, one had recently become uninsured, and one recently had obtained oral health insurance. Two of the families who reported taking their children to the dentist only for treatment of cavities also said they would wait to treat the child's cavities when they next went to Japan. These families had lived in the US less than five years.

The two families covered by QUEST said that they were willing to take their children for dental check ups in Hawai‘i every six months as long as it was very cheap (<$10) or free of charge. They emphasized that if the check-up cost more than $10, they would feel a financial burden and would reduce the frequency of dental check-ups for children.

Other families, however, seemed to not mind paying the co-pay required with private insurance for dental check-ups. Even families with financial difficulty stated that they preferred to take advantage of oral health insurance since they paid a lot for it. They usually mentioned that treatment would cost much more than prevention.

The family that had recently decided to cancel oral health insurance went for a check-up before canceling to take advantage of the free check-up. However, the mother did not make an appointment for next check-up. She said she would no longer take her

child to dental clinic in Hawai‘i to check-up or basic treatment after the insurance period, unless emergency happened, such as an injury.

Language of dentists

Nine out of ten families said their main resource of reliable information to select dentists in Hawai‘i was Japanese friends who also were taking care of children in Hawai‘i. Only one mother used online information to find a dentist who could speak Japanese. Two out of six families visiting English-speaking dentists mentioned that they actually preferred Japanese-speaking dentists. Even though there are at least three dentists who can speak Japanese fluently in Hawai‘i, they are not all pediatric dentists. Therefore, some parents took children to English-speaking dentists, despite their preference. Some of them did not have any problems visiting English-speaking dentists for oral health care of children, since most mothers' English levels were good enough to communicate in English, and parents are used to American culture including dental care. In addition to language limitations, some preferred to visit Japanese dentists to receive similar treatments that Japanese dental clinics provide, as they felt it was more reliable and familiar. Some parents mentioned that dentists in Hawai‘i tended to provide more treatments and higher frequency of X-rays than those in Japan.

Table 16. Oral Health of children

		# of families
Oral health insurance for elementary school age children	Uninsured QUEST Private Government (Military)	3 2 4 1
Cavities of children	Never Past Present or recent	4 3 3
Frequency of brushing teeth	Once a day Twice a day	4 6
Dental check-up	Zero - once / year Twice / year (Every six months) More than twice / year	2 6 2
Language spoken by dentists in Hawai‘i	English	6

	Japanese Never visit dentists in Hawai‘i	3 1

Table 17 summarized the facilitating factors and barriers to prevent cavities of children generated from the data of interviews. The top three facilitating factors and barriers are shown in italic. They were identified as common factors among many interviewees as well as causes of other factors.

Table 17. Barriers and facilitating factors *(top three factors in Italic)*

Theme	Barriers	Facilitating factors
Insurance	*Uninsured status*	*Insured status / Social support for the low-income (QUEST)*
Cost	High cost of insurance	*High cost of insurance / treatment*
Knowledge	Limited knowledge of prevention	Knowledge about preventions (importance/methods)
Language	No Japanese speaking pediatric dentist	Japanese speaking dentists
		Information in Japanese
Support	Limited support by fathers	Support in communities
Culture in U.S.	Dietary habit in U.S.	Satisfaction about oral care in U.S.
	Adaptation for new cultures by mothers	*Appointment system*
Other	*Hesitation to ask question to dentists*	Parental experience with cavities
		Social norm
		High / Enough household income

Barriers

<u>Uninsured status and limited knowledge of prevention</u>

Uninsured families tended to take their children for check-up less frequently than insured families, and thus they had fewer opportunities to learn prevention methods, such as topical fluoride, fluoride pills, or sealant. Fear for high cost, which they could not predict, also made them hesitant to take children for treatment at earlier stages of cavities. Below are examples of statements made by the participants.

- “Since my children are not covered by an oral health insurance in Hawai‘i, I am worried about the price of dental care here. I cannot even expect how much it will be.”
- “I would take my kids to dental clinics if we were in Japan, because the cost of treatment is much cheaper.”
- “I have not thought about preventions of child cavities except brushing teeth.”

<u>High cost of insurance</u>

Since the cost of dental care in Japan is much cheaper than in the U.S., most of interviewers complained about the high cost of dental care and insurance. One family used to live in the city where medical and oral health care for children under 15 years old was totally free of charge, regardless of family income. Those people who were recently used to free or low-cost of dental care in Japan tended not to pay much attention to cavity prevention, even in Hawai‘i. In addition, they tended to feel financially burdened by the costs of oral health care in Hawai‘i, regardless of their income level. Those who still had oral health insurance in Japan preferred to visit dentists in Japan due to fear of unpredictable cost in the U.S. Below are examples of statements made by different participants on the cost of insurance.

- “Since an insurance for oral health was costly, I did not enroll.”
- “Check-up (without insurance) costs $150 a time for a child. In addition, the dentist always finds new cavities, so that I do not want to take my children to check-up that frequently (twice a year).”

<u>No Japanese speaking pediatric dentist</u> and h<u>esitation to ask question to dentists</u>

Japanese parents tended not to directly ask dentists any questions. Even if they did not understand English, or they were not familiar with prevention approaches, they tended to pretend to agree with professionals without argument or confirmation of facts. This was not only for mothers with English-language limitations who took children to

English-speaking pediatric dentists but also for mothers without English-language limitations.

In consequence, despite outwardly obedient attitudes common in the Japanese culture, there was low compliance with recommendations in some areas. For example, two out of three families prescribed fluoride pills by pediatricians did not let their children take them at home due to fear of side effects. But they did not mention their fear or ask about the safety of this prevention measure to dentists directly. Instead, they decided not to comply based on information from friends. In addition, even though at least five families were recommended to help their children to use dental floss, three families did not follow the recommendation due to busy schedules. Several parents also had concerns about the difference between dental care in Japan and the U.S., but they said they never spoke about these concerns directly with dentists. They tried to ask friends around them, but most of them did not have professional knowledge, so concerns and worries tended not to be addressed. Below are examples of statements made by the participants.

- "Even though our dentist recommended to use floss, we usually don't use it. Because I'm afraid that the filling of cavities may come out by flossing."
- "I did not give children that prescribed fluoride pills, since it is kind of an awkward."

<u>Limited support by fathers</u>

Although fathers played important roles in the family, these were not usually active in the area of providing oral health care or educating children about healthier eating habits. Based on the situations described by mothers, mothers did most of the childcare, whether or not the father was absent or present, employed or unemployed. Most mothers felt that fathers did not take much responsibility for the child's oral health. For example, a mother said that she "fired" a father from supervising the children's tooth

brushing because of his irresponsible support behaviors and subsequent cavities in the children. Below is an example of statements made by the participants.

- “My husband plays with the kids but is not good at taking care of them.”

Dietary habit in the U.S.

Six out of ten interviewed families voluntarily came up with dietary issues in Hawai‘i as one of main causes of cavities. Compared to Japan, they were surprised by the amount and frequency of sugary snacks. They also seemed to be uncomfortable about the system of having snack time at schools in the U.S., since it is prohibited to bring snacks to schools in Japan. Many Japanese interviewees tended to think Americans do not care about the amount and balance of food. They felt such unhealthy behavior, as well as less appreciation for food and careless attitudes to waste food, increased the risk of cavities of their children. Below are examples of statements made by the participants.

- “Americans eat surprisingly a lot. Seriously too much.”
- “Americans do not mind wasting food, and do not educate children about what healthy food is.”
- “I have never seen Americans eating healthy snacks. They keep eating and drinking all day, such as soda, junk food, and sugary snacks.”
- “Even though I am worried about overweight American children, their parents worried about our skinnier kids.”
- “Due to the American culture of feeding children frequently even at schools, my children ask for snacks more frequently at home after we moved to Hawai‘i. Even Japanese families living in the U.S. for several years tended to have Americanized dietary.”

Adaptation for new cultures by mothers

Most Japanese families did not have the custom of dental check-up when they lived in Japan because annual mandatory check-ups by dentists are provided in all elementary and secondary schools in Japan. Many interviewees mentioned that they did not have the habit of visiting dental clinics for check-ups, and they were not familiar with most prevention methods available in the U.S.

Facilitating factors

Insured status, high cost of insurance / treatment, and knowledge about preventions

While lack of insurance was a barrier, families with oral health insurance tended to take advantage of both the preventive and treatment services covered by the insurance. Even if they had to pay co-pay for check-up or treatment, they did not mind the small price compared to the high price of insurance. Through such frequent use of dental care, parents had opportunities to learn about prevention methods and their importance. This suggests that investment by purchasing high price of insurance can encourage parents to use oral health care in preventive ways to avoid paying high cost treatment. Also, the system of making appointments in advance made them feel obligated to participate in the next scheduled check-up. Below are examples of statements made by the participants.

- "Since we are always asked schedule for check-up in six months, we simply visit on the day again."
- "The insurance is very costly. But treatment of cavities will cost more. That's why I would like to prevent my children's cavities as much as possible."
- "Since the part of cost for check-up are covered by insurance, it would be better to find cavities at earlier stage and treat them soon."

Health care support for the low-income (QUEST)

Families with children covered by QUEST also participated in check-ups and treatment visits. Parents did not need to pay anything to enroll in the insurance or to use

dental care due to limited household income. But these parents knew oral health care was costly, so they took advantage of the QUEST-covered oral health services. Below is an example of statements made by the participants.

- "Since my children are covered by QUEST, check-up every six months and basic treatment are free of charge. So the cost is not problem for us. But if it costs, we will reduce the frequency to visit dental clinics."

Most of families had the same oral health insurance for all of their children. However, for one family, the two children born in Japan were covered by the mother's tourist insurance (which does not cover oral health) and the youngest child, which was born in Hawai'i, was covered by QUEST. The mother provided several reasons why she could not provide oral health care for older children, but she said she did not mind taking the youngest for check-ups or treatments because of the coverage by QUEST.

Japanese speaking dentists and information in Japanese

There are at least three Japanese-speaking dentists in Hawai'i. In addition, due to large population of Japanese living in Hawai'i, much information is available in Japanese. Such environment seemed to help English-limited parents to access to dental care in Hawai'i. Below is an example of statements made by the participants.

- "I don't have any language barriers with our dentist since he can speak fluent Japanese."

Support in communities

Nine out of ten interviewed mothers mentioned that they have close Japanese friends in Hawai'i who they can rely on for information and help. Among them, two families relied on both Japanese and local American friends, while seven families relied only on Japanese friends in Hawai'i. No one clearly mentioned the reasons why they preferred Japanese friends to local Americans or people from outside of Hawai'i with

similar situations. Even after living in the U.S. for more than ten years, or even if they spoke English fluently, the majority of Japanese preferred Japanese friends and they tended to be willing to help each other. Below are examples of statements made by the participants.

- “After having a child, the numbers of Japanese friends in Hawai‘i increased dramatically through the activities for the child.”
- “Since most of us have similar situations without family’s support from close relatives, we tend to be willing to support each other.”
- “I don’t like to gather for backstairs gossip which many other Japanese mothers prefer. But there are enough Japanese in Hawai‘i for mothers like me to form the other group.”
- “Since we need to support each other to manage childcare in Hawai‘i, I feel I have more real friends in Hawai‘i compared to surface friends in Japan.”

<u>Satisfaction about oral care in the U.S.</u>

Many parents were satisfied with the friendly attitudes of dentists and clinic staff in Hawai‘i. Parents who took children to see pediatric dentists in Hawai‘i tended to feel that oral health services for children were much better in the U.S. than in Japan. Below are examples of statements made by the participants.

- “My children love to visit the dental clinic since they can choose goodies after treatment. Interior is also very cheerful and decorated by popular characters. It is very different from Japan.”
- “Dentists (pedodontists) and staff at clinics in Hawai‘i are much more friendly and kind to children. I feel they are professionals for children’s care. There are even TVs to entertain children during treatment.”
- “In the U.S., dentists explain details before treatment one by one.”

Appointment system

Eight families took children for dental check-ups every six months or more frequently. The main reason for the regular appointments seemed to be the system used by dentists' offices to make future appointments on the day of the check-up. They felt obligated to visit again on the day as they were recommended to do so by dentists. Even if there were schedule conflicts on the day, they reschedule and visit clinics anyway.

Parental experience with cavities

Seven out of eleven interviewees voluntary mentioned that their own experience with having many cavities during their childhood was one of main reasons they were trying to prevent cavities of their children. Below are examples of statements made by the participants.

- "Since I used to have many cavities, I really hope I can help preventing cavities for my children."
- "I had to go to dentists for treatments so frequently when I was young. And I hate it. That's why I don't want to let my child suffer from such situation."

Social norms

Parents tended to feel it was their responsibility to prevent their children's cavities. When children developed cavities, many parents, especially mothers, tended to feel disappointed at their own carelessness even though they tried to prevent cavities. Also, interviewees mentioned that the peer pressure from Americans, who cared about oral health more than Japanese, tended to encourage Japanese parents to provide more oral health care for children. Below are examples of statements made by the participants.

- "Prevention of cavities is the responsibility of parents. I feel it's shame for my child to develop cavities."

- “I think people with many cavities tend to be considered as loose persons.”
- “I admire many Americans’ whiter and even teeth.”
- “Dental check-up twice a year is usual in the U.S.”

High / enough household income

Japanese families living in Hawai‘i had relatively higher income than other immigrants from other countries. Such high or enough household income seemed to help them to access to oral health care. Many families felt financial burden for oral health care cost in the U.S., but all interviewed families were able to afford the cost.

Discussion

This study examined the practices of Japanese nationals living in Hawai‘i to identify barriers and facilitating factors in preventing cavities in their children. The main barriers were found to be uninsured status, slow adaptation to U.S. oral health system by Japanese mothers, and Japanese hesitancy to ask questions. The main facilitating factors were having oral health insurance coverage (either through QUEST or private insurance), high cost of insurance and treatment, and the U.S. check-up appointment system.

These findings are concordant with previous research that found that financial and cultural barriers can reduce immigrants’ access to dental care (Dong et al., 2011). This study specifically found that Japanese parents who lived in the U.S. for only a few years were less likely to promote cavity prevention behaviors in their children or provide their children with oral health insurance compared to parents who had lived in the U.S. for a longer period of time. Also, insurance status was the most significant issue for parents in taking their children for dental check-ups and treatment. Thus, children without oral health insurance had more cavities than children with insurance (Data Resource Center for Child & Adolescent Health, 2007; Edelstein, 2002).

Few individuals in my sample were low income. Surveillance data suggest that Japanese in Hawai‘i have a higher average income than other ethnic groups. However, it was not possible to check average income of the sample against average income of

all Japanese nationals living in Hawai‘i because income data are not published for Japanese residents by place of birth or how recently a person moved to the U.S. However, the U.S. has visa policies in place requiring foreign nationals to prove adequate financing to stay in the U.S.

The literature also suggests that limited-English proficiency on the part of parents is associated with children’s cavities (Maserejian et al., 2008). However, it does not appear to be a barrier for Japanese parents living in Hawai‘i because there are at least three dentists in Hawai‘i who can speak Japanese fluently. Two of them are Japanese with working experience as dentists in Japan, and the other is a Japanese-American who studied in Japan. Also, most of interviewed mothers said they knew enough English to live in English-speaking countries by themselves. Even though having poor English language skills was not a major barrier for them, the findings from this study suggested cultural factors that prevent parents from asking questions or communicating their reluctance with dentists.

Findings from this study also suggest that recently arrived Japanese parents may be passive about preventing child cavities. This may be due to the fact that Japan offers universal health coverage for health and oral health care, with low-cost or no-cost treatment. In addition, dentists visit all public schools in Japan each year to check children’s teeth and refer children to treatment as needed. Thus, in Japan, parents do not need to think proactively about cavity prevention, check-ups, and treatment.

This study also found that Japanese national parents realized that dental care and oral health insurance costs are expensive in the U.S. Thus, recent arrivals were more likely to go without insurance and instead take children back to Japan for oral health checks. On the other hand, Japanese nationals with oral health insurance in Hawai‘i (private or QUEST) took advantage of it by participating in preventive services.

Findings confirm that different contexts faced by parents in the U.S. and Japan lead to different levels of cavity risk for children. These different contexts are summarized in Table 18. Specifically, people living in Japan tend to rely on free annual check-up through the school, and only take children to dentists when alerted to a problem identified through the school check-up. Oral health treatment in Japan is free or

low-cost. Thus, the Japanese system encourages parents to be reactive, only taking action when they realize a need for treatment. When they arrive in the U.S., they may not know how to attend to the oral health care of their children and they may feel that the cost of oral health insurance and treatment in the U.S. is too costly. However, because the dietary habits in U.S. put children at greater risk from cavities, a parent in the U.S. must adjust into a new culture in which they must take more responsibility for preventing cavities in their children. Those who are covered by QUEST and those who secure private insurance tend to learn about and take advantage of preventive services as well as treatment. Such parental attitude seemed to reduce the risk of cavities among children of Japanese.

Table 18. Difference of Japanese parents' tendency for providing dental care for children living in the U.S. and Japan

Living country	**U.S.**			**Japan**	
Dietary risk	High			Low	
Household income	Not low	Low		Not low	Low
Insurance status	Insured	Uninsured	QUEST (Medicaid)	Insured	Insured (Social welfare)
Cost of insurance	Costly	Free	Free	Low-cost	No cost
Cost of prevention	Covered partially	Costly	Free (Basic methods)	No coverage	No coverage
Cost of check-up	Covered partially	Costly	Free	Free (Provided at schools)	Free (Provided at schools)
Cost of treatment	Covered partially	Costly	Free (Basic methods)	Low-cost or free	Free
Attitude to access for oral health care	Prefer to use benefit	Fear for cost/ Hesitation of usage	Prefer to use benefit	Use when needed	Use when needed
Frequency of check-up	Every 6 months	No/Less	Every 6 months	No/Less	No/Less
Knowledge of prevention	Yes	No	Yes	No	No
Treatment	At earlier stage	Delay/When needed	At earlier stage	When needed	When needed

Parents' tendency	Active	Inactive	Active	Passive	Passive
Risk of cavities	Low	**High**	Low	Moderate	Moderate

Dentists or oral health professions who are working for Japanese families living in Hawai‘i seemed to be taking an important role to oral health of children. However, they should make sure that Japanese parents really understand and agree to follow their recommendations. Many of Japanese parents seem to feel uncomfortable asking questions, even of kind and friendly dentists. Even if they seem to agree, it would be helpful to explain recommendations clearly, ask parents if they have any concerns, and follow-up to see if behavioral changes are made, especially related to unfamiliar practices such as flossing and use of fluoride.

Interviewees that had become familiar with the U.S. oral health care system felt that U.S. dental care was of higher quality than Japan dental care. A Japanese dentist working in Hawai‘i explained that this was related to the Japan reimbursement system, which fixes the amount that Japanese dentists can charge. Thus, some Japanese dentists may use less costly but perhaps inferior materials in their practice. Individuals in the U.S. can visit dentists that may provide superior care with superior materials if patients agree to pay the dentist more than insurance reimburses for the care.

Limitation

Since this study aimed to study barriers and facilitating factors of Japanese national parents living in Hawai‘i in preventing cavities in their children, all of interviewees were Japanese. Therefore, the findings may not be able to apply for people from other countries living in Hawai‘i. For example, it appears that most of Japanese nationals living in Hawai‘i are not low-income and have access to Japanese-language information and services. Thus, their living situation may be different than other immigrant groups in Hawai‘i. Also, these findings may not apply to Japanese living outside of Japan, but not in the U.S., as dental care practices are clearly tied to the context of the country.

Also, the results of this study need to be interpreted carefully due to the small sample size. Even though the interviewer made efforts to recruit interviewees through various resources, two interviewees were known to the interviewer, and four were introduced through friends of the interviewer. Snowball recruitment may have resulted in a more homogenous sample than expected, although efforts were made to recruit interviewees with a diversity of situations. Also, it is likely that parents who are in relatively stable situations and perhaps confident about the oral health of their children may have been more willing to participate in the study than parents who are extremely busy, who are illegal immigrants, or who are in unstable situations. In addition, since all of interviewers were recruited from the island of O‘ahu, Japanese families living in neighbor islands may have different situations.

Recommendations

Regardless of household income, insurance status seems to be a major factor on child dental care for most Japanese families living in Hawai‘i. Insurance status was associated with the length of mother’s experience living in the U.S. Since there seems to be few low-income Japanese in Hawai‘i due to visa regulations, oral health insurance of children should be mandatory for all Japanese parents to encourage them to use oral health service in Hawai‘i.

It is also important to educate Japanese mothers who have lived in the U.S. for less than five years about the importance of prevention and the cost-effectiveness for check-up. Also, it must be important to educate fathers to share in the responsibility of keeping their children healthy and preventing cavities of children.

Since many Japanese families tended to rely on other Japanese families as information resources, it may be effective to provide oral health education for parents at Japanese schools in Hawai‘i. Provided information could reach the target population easily, and the information will spread among Japanese communities, including families without access to such schools.

In addition, it is important for dentists to confirm that Japanese parents understand and agree with cavity prevention methods. Dentists should ask if parents

have any concern, since many Japanese nationals tend to feel hesitate to speak out. Special supports are needed for foreigners who have not adopted in U.S. culture and to low-income families who may be unaware of QUEST.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

Taken together, these three studies lead to several conclusions. The systematic literature review and the quantitative study found strong evidence of the effectiveness of providing FMR in schools in Japan. In the absence of systemic water fluoridation, this appears to be a culturally competent approach to reducing cavities in children in Japan. Coupling FMR use with oral health education may lead to even better oral health outcomes for children.

Providing FMR in the schools will supplement the strong policies that the Japanese government already has put in place to address oral health care needs of children. Specifically, the Japanese government has been providing opportunities of dental check-up for all school age children at schools for about 60 years. The government also has increased the number of dentists and reimburses dentists so that all individuals can access free or low-cost dental care.

However, the qualitative study showed that such generous supports may have made Japanese passive about oral health, so that they are not engaging in good cavity prevention practices at home or abroad. Especially, when they moved outside of Japan, it seemed to take time to adjust for a different oral health care system. For example, even though most of Japanese living in Hawai‘i have good financial status, not all of them enrolled in oral health insurance. Lack of insurance reduces access to oral health care and leads to higher risk of oral health problems for children. Parents who used to be supported by government in Japan needed time to realize the importance of being active for their children’s oral health care in the U.S. Japanese parents who grew up in Japan also realized the importance of the prevention of cavities only after they moved to the U.S. They became more serious when they had to pay expensive insurance cost or treatment. Such financial burden may be effective for parents to be more responsible for oral care of their children. In addition, selective social supports such as QUEST for the low-income families also worked effectively for Japanese families living in Hawai‘i to provide adequate oral health care for children. Instead of providing systematic supports as does Japan, needs-based support like those in Hawai‘i may be more cost-effective for improving oral health of children.

On the other hand, the government of Hawai‘i needs to realize the needs of parents who recently relocated from other countries. Those parents might have limited knowledge about the importance of prevention and low motivation to provide prevention methods for child oral health. They might not realize the risk from U.S. culture, such as the popularity of sweet drinks and snacks, and the practice of allowing children to consume them in school. Since there are many immigrant families living in the state of Hawai‘i, culturally competent supports are needed to improve children’s oral health conditions depending on their needs.

As a prevention method, a school-based FMR program may be very effective in Hawai‘i. Like Japan, the most of water (89.2%) in Hawai‘i is not fluoridated (Centers for Disease Control and Prevention, 2011). Since school-based intervention can reach many children, such prevention programs at schools can minimize oral health disparities and improve oral health conditions of many children. However, the evidence-based information should be provided in the way people in communities without an academic background can understand.

Finally, this dissertation demonstrated the usefulness of taking a comprehensive approach to understanding predictors of oral health of children. This type of analysis can lead to the identification of culturally unique associations (such as numbers of convenience stores and cavities in Japan), which could be studied further.

As a conclusion, evidence-based prevention methods and needs-based social supports are needed in Japan and Hawai‘i, since every child should have a fair chance in realizing good oral health conditions.

APPENDICES (consent forms)

University of Hawai'i

Consent to Participate in Research Project:

The Barriers to and Needs of Immigrant Japanese Parents

My name is Sakiko Yasuda. I am a graduate student at the University of Hawai‘i at Manoa in the Department of Public Health. As part of the requirements for earning my graduate degree, I am doing a research project. The purpose of my project is to examine the barriers and needs for caregivers, such as parents, to provide appropriate prevention of cavities for children in Hawai‘i . I am asking you to participate because you are taking care of child or children in elementary school and you are now living in Hawai‘i.

Activities and Time Commitment: If you participate in this project, I will meet with you for an interview at a location and time convenient for you. The interview will consist of 10-20 open-ended questions. The interview will take about 30 minutes. Interview questions will include questions like, “How do you support your children to prevent cavities?” “Do you have any difficulty to provide this support? If so, what kind?” Only you and I will be present during the interview. I will audio-record the interview so that I can later transcribe the interview and analyze the responses. You will be one of about 15 people that I will interview for this study.

Benefits and Risks: There will be no direct benefit to you for participating in this interview. The results of this project may help advocate for interventions for better oral health, and findings may benefit future Japanese children in Hawai‘i. I believe there is little risk to you in participating in this research project. You may become stressed or uncomfortable answering interview questions or discussing topics with me during the interview. If you do become stressed or uncomfortable, you can skip the question or take a break. You can also stop the interview or you can withdraw from the project altogether.

Privacy and Confidentiality: I will keep all information in a safe place. Only my University of Hawai‘i advisor and I will have access to the information. The University of Hawai‘i Human Studies Program has the right to review research records for this study. After I write a copy of the interviews, I will erase or destroy the audio-recordings. When I report the results of my research project, I will not use your name. I will not use any other personal identifying information that can identify you. I will use a code number to describe you instead of your name, and I will report my findings in a way that protects your privacy and confidentiality to the extent allowed by law.

Voluntary Participation: Your participation in this project is completely voluntary. You may stop participating at any time. If you stop being in the study, there will be no penalty or loss to you.

You will receive a $10 gift certificate to either Longs or Safeway or Foodland or Starbucks for your time and effort in participating in this research project.

Questions: If you have any questions about this study, please call or email me at 808-485-9650 / sakikoy@hawaii.edu. You may also contact my adviser, Dr. Kathryn Braun, at 808-330-1759 /

kbraun@hawaii.edu. If you have questions about your rights as a research participant, you may contact the UH Human Studies Program at 808-956-5007 / uhrib@hawaii.edu.

If you agree to participate in this project, please sign and date the signature page and return it to Sakiko Yasuda, Principal Investigator at the University of Hawai'i.

Please keep the section above for your records. If you consent to be in this project, please sign the signature section and return it to Sakiko Yasuda.

Signature for Consent:

I give permission to join the research project entitled, *The Barriers to and Needs of Immigrant Japanese Parents in Hawai'i in Preventing Cavities in Their Children."*

Please initial next to either "Yes" or "No" to the following:

I consent to participating in this research project. _____ Yes _____ No

I consent to be audio-recorded for the interview portion of this research. _____ Yes _____ No

Name of Participant (Print): _____

Participant's Signature: _____

Signature of the Person Obtaining Consent: _____

Date: _____

研究参加同意書:

ハワイ在住の日本人家庭における子どもの虫歯予防に関する研究

ハワイ大学医学部公衆衛生学専攻博士課程に在籍する安田咲こと申します。卒業論文作成のために子どもの虫歯予防に関する研究をしています。本研究ではハワイに在住されている日本人の保護者の方々にとって、子ども達の虫歯を予防するために障害となっていることや、保護者の方々が必要とされている支援などについて調査しています。そのため、本研究ではハワイにお住まいで、小学生のお子様を養育されている保護者の方に率直なご意見を伺う予定です。

日時・場所・内容：研究にご参加頂けるのであれば、インタビューのために日時と場所を調整させて頂きます。場所は参加者のご自宅、公園、図書館、公共施設など、参加者のご都合に会わせて決めさせて頂きたいと思います。インタビューは２０問程度の質問をもとに３０分～１時間程度ご意見を伺う形で、「どのようにお子様の虫歯予防をされていますか？」「お子様の虫歯予防に関して困っていることはないですか？」等の質問を予定しています。インタビューは研究者（安田）と参加者（あなた）のみで実施する予定です。 また、インタビュー内容を記録し分析するために、インタビューは録音させて頂きます。

利益と損害について：残念ながら、この研究に参加して頂くことで、直接参加者の利益となることはございません。しかし、本研究の調査結果は虫歯の予防に関して、将来的にハワイで暮らす日本人家庭の子ども達への効果的な支援策を探求するために役立つことが期待されています。また、この研究に参加されることで生じる損害はほとんど無いと想定しております。インタビュー中に不愉快に感じたり、質問に答えたくないと感じることがあるかもしれませんが、その場合には質問を飛ばしたり、途中でインタビューを中断または中止することも出来ます。

個人情報の保護について：参加者の個人情報は厳重に管理・保護されます。研究者（安田）とハワイ大学のアドバイザーのみがその情報を管理します。また、ハワイ大学の研究倫理委員会も本研究に関する情報を閲覧する権限があります。インタビュー内容を文書化後、インタビューの録音記録は破棄されます。研究結果を発表する際に参加者の氏名などの個人情報は一切公表されません。個人名のかわりにコード番号を使う等の方法で個人が特定されない形で研究内容の発表を行い、参加者のプライバシーを保護します。

その他：この研究への参加は参加者の意志に基づきます。インタビューの途中で中断することや、インタビューへの参加を中止することも出来ます。また、そのことによって不利益は生じません。インタビューにご協力いただいた方には薄謝として１０ドル分のギフトカードを差し上げます。

本研究に関して質問などがございましたら、下記へご連絡ください。

主任研究者：安田咲こ　(Sakiko Yasuda) ハワイ大学医学部公衆衛生学専攻博士課程 3 年

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研究参加者の権利についての質問等がございましたら、直接ハワイ大学へ連絡していただくことも可能です。UH Human Studies Program 808-956-5007 / uhrib@hawaii.edu（倫理審査承認番号：CHS #22904）

別紙の説明書をお読みになり、担当者（安田）の説明を聞いて、インタビューへの参加に同意される場合は､下記の同意書にサインして下さい。

インタビュー参加同意書:

私は本研究（研究の題名：ハワイ在住の日本人家庭における子どもの虫歯予防に関する研究）に参加します。

I give permission to join the research project entitled, *The Barriers to and Needs of Immigrant Japanese Parents in Hawai'i in Preventing Cavities in Their Children."*

以下の項目で同意される箇所にチェックをお願いします。

Please initial next to either "Yes" or "No" to the following:

私はこの研究への参加に同意します。

I consent to participating in this research project. _____ Yes _____ No

私はインタビューの録音に同意します。

I consent to be audio-recorded for the interview portion of this research. ___ Yes ___ No

参加者氏名(ローマ字表記)

Name of Participant in English (Print): _____

参加者のサイン

Participant's Signature: _____

研究実施者氏名

Signature of the Person Obtaining Consent: _____

日付

Date: 2015 年_____

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