Dietary Evidence from a Dental Practice-based Research Network

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1 Introduction

According to both the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO), dental caries is the most common chronic disease affecting children and adolescents (World Health Organization, 2012; Centers for Disease Control and Prevention, 2012). Indeed, dental caries affects 60–90% of school-aged children and almost 100% of adults. As oral health is essential for general health and quality of life, the high prevalence of this disease is concerning, and highlights the importance of applying public health approaches to the prevention of dental caries.

Dietary factors are important and modifiable factors in the prevention of dental caries. The potential public health role of general dental practitioners in providing lifestyle advice to their patients has also been recognized as an important factor (Dyer & Robinson, 2006). Previous studies have provided evidence that one-to-one dietary interventions in the dental setting can change the dietary behavior of practitioners and patients (Harris, Gamboa, Dailey, & Ashcroft, 2012). The American Dietetic Association recommends collaboration between dietitians and dental professionals for oral health promotion and disease prevention and intervention (Touger-Decker & Mobley, 2007). However, the evidence regarding the association between diet and dental caries is limited. One possible reason is the private nature of most dental practices, which creates a barrier to the collection of large-scale data.

In overcoming this barrier, the new research model, termed the dental practice-based research network (Dental PBRN), holds great potential in enabling larger-scale clinical research. Dental practice-based research is a form of research conducted in clinical practices by dental practitioners and their staff. It is designed to resolve the issues faced by dental clinicians during the routine care of their patients. This chapter aims to describe and explore this new research model by 1) reviewing the current dietary evidence collected from clinical epidemiology research, 2) describing the Dental PBRN, and 3) presenting the results from research conducted using the Dental PBRN model.

2 Review of Evidence Regarding Dietary Intake and Dental Caries

This section provides an overview of the evidence regarding an association between dietary/nutritional patterns and the development of dental caries, which is largely a preventable disease (Balakrishnan, Simmonds, & Tagg, 2000; Rank, Julien, & Lyman, 1983; Reich, Lussi, & Newbrun, 1999). According to Zero et al., dental caries development is a dynamic dietomicrobial disease involving cycles of demineralization and remineralization (Zero et al., 2009). The early stages of this process are reversible by modifying or eliminating etiologic factors (e.g., modifying diet and/or removing plaque biofilm), and increasing exposure to protective factors (e.g., fluoride) and/or salivary flow (Zero, et al., 2009). This chapter focuses on the role of dietary factors in dental caries development.

Table 1 shows the results of a WHO analysis of the evidence linking diet to dental caries development (Moynihan, 2005). As can be observed, the factors with the strongest evidence for a link to an increase in caries development are frequent intake of free sugars and intake of a high amount of free sugars, followed by undernutrition. The factor with the strongest evidence for a link to a decrease in caries development is fluoride exposure, followed by consumption of hard cheese and chewing of sugar-free gum. Further, there may be a link between a decrease in caries development and consumption of xylitol, milk, and dietary fiber. When focusing on food, intake of sugars (increased caries development), dairy foods (decreased caries development), and dietary fiber (decreased caries development) might relate to dental
caries development. This section briefly reviews the findings which WHO’s report focused on regarding these dietary factors although association between dental caries and other dietary factors such as vitamin D (Hujoel PP, 2013; Grant WB, Boucher BJ, 2011; Grant WB, 2011) were pointed out.

<table>
<thead>
<tr>
<th>Evidence*</th>
<th>Convincing</th>
<th>Probable</th>
<th>Possible</th>
</tr>
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<tbody>
<tr>
<td>Increased caries risk</td>
<td>Sugars (intake amount and frequency)</td>
<td>Dairy (hard cheese)</td>
<td>Undernutrition</td>
</tr>
<tr>
<td>Decreased caries risk</td>
<td></td>
<td>Dairy (milk)</td>
<td>Dietary fiber</td>
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</table>

Table 1: Summary of the strength of evidence regarding the link between dietary factors and dental caries development (the modified WHO report; (Moynihan, 2005))

2.1 Intake of Sugars

Here, the term “sugars” refer to all monosaccharides and disaccharides, while the term “sugar” refers only to sucrose. The WHO report pointed out the existence of a wealth of evidence from many different types of investigations, including human studies, animal experiments, and experimental studies both in vivo and in vitro, showing the role of dietary sugars in the etiology of dental caries (Moynihan, 2005).

Several randomized controlled trials (RCTs) have been conducted to clarify the amount and frequency of consumption of sugars that affects the development of dental caries. The Vipeholm study, which was conducted in an adult mental institution in Sweden between 1945 and 1953 (Gustafsson, 1952), revealed that increased frequency of consumption of sugars between meals is associated with higher risk of dental caries, and suggested that an increase in dental caries development disappears upon a decrease in consumption of sugar-rich foods. The Turku RCT, a study of adults in Finland in the 1970s, found that an almost total substitution of sucrose in the diet with xylitol, a non-cariogenic sweetener, resulted in an 85% reduction in dental caries over a 2-year period (Scheinin, Mäkinen, & Ylitalo, 1976). Several animal studies and longitudinal studies have also indicated a relationship between amount of sugars consumed and dental caries development (Burt et al., 1988; Hefti & Schmid, 1979; Kleemola-Kujala & Rasanen, 1982). Nevertheless, whether the frequency or amount of sugars consumed is a stronger factor in dental caries development remains unclear: both factors appear to be important (Moynihan, 2005).

One limitation while comparing the results of RCTs conducted several decades ago to the results of recent studies is that a proportion of the current population has adequate exposure to fluoride (Burt &

* Evidence level is defined by WHO as follows: **Convincing evidence**: Evidence based on epidemiological studies showing consistent associations between exposure and disease, with little or no evidence to the contrary. The available evidence is based on a substantial number of studies including prospective observational studies and where relevant, randomized controlled trials of sufficient size, duration and quality showing consistent effects. The association should be biologically plausible. **Probable evidence**: Evidence based on epidemiological studies showing fairly consistent associations between exposure and disease, but where there are perceived shortcomings in the available evidence or some evidence to the contrary, which precludes a more definite judgement. Shortcomings in the evidence may be any of the following: insufficient duration of trials (or studies); insufficient trials (or studies) available; inadequate sample sizes; incomplete follow-up. Laboratory evidence is usually supportive. Again the association should be biologically plausible. **Possible evidence**: Evidence based mainly on findings from case–control and cross-sectional studies. Insufficient randomized controlled trials, observational studies or non-randomized controlled trials are available. Evidence based on non-epidemiological studies, such as clinical and laboratory investigations, is supportive. More trials are required to support the tentative associations, which should also be biologically plausible.
Pai, 2001). Since it would not be possible to conduct RCTs to investigate how consumption of sugars affects dental caries today because of ethical issues, Burt and Pai conducted a systematic review that investigated the importance of intake of sugars in caries etiology in populations exposed to fluoride. Based on their findings, they concluded that consumption of sugars is a moderate risk factor for caries development in most people who have adequate exposure to fluoride, and a more powerful risk factor in people who do not have regular exposure to fluoride (Burt & Pai, 2001). Thus, restriction of the consumption of sugars remains a factor in the prevention of caries in situations where there is widespread exposure to fluoride, although it is not as strong a factor as where there is not widespread exposure to fluoride (Burt & Pai, 2001).

2.2 Hard Cheese Intake

The WHO report categorizes hard cheese intake as a “probable” factor in decreasing caries development (Moynihan, 2005). Stimulation of salivary flow, inhibition of plaque bacteria, and delivery of high amounts of calcium and inorganic phosphate have been suggested as the possible mechanisms by which hard cheese intake reduces cariogenicity (Kashket & DePaola, 2002). To explore the in-situ rehardening effect of hard cheese, Gedalia *et al*. and Sela *et al*. (Gedalia, Davidov, Lewinstein, & Shapira, 1992; Sela *et al*., 1994) intraorally exposed vitro-etched enamel slabs prepared from human teeth to 1 of 2 substances for 5 minutes: 1) parafilm-stimulated salivary secretions or 2) cheese compounds and saliva resulting from mastication of 20 g of hard cheese (Sela, *et al*., 1994). Their results suggested a significantly higher level of rehardening in the group that consumed cheese.

Only a few clinical studies have attempted to clarify the association between hard cheese intake and dental caries development. In a 2-year observational study in the United Kingdom comparing 65 children who developed no caries with 71 children with the highest 2-year caries increment (≥7 decayed missing filled teeth: DMFS), Rugg-Gunn et al. found that mean daily cheese intake was not associated with dental caries development (Rugg-Gunn, Hackett, Appleton, Jenkins, & Eastoe, 1984). The relationship between hard cheese intake and dental caries development reached statistical significance when they limited 19 children who had been caries-free at the beginning of the study and had developed no caries lesions during the study and the 23 children who had the highest caries experience (≥ 20 DMFS). Moreover, the researchers did not adjust for possible demographic and behavioral confounders such as tooth brushing frequency, use of fluoride, and between-meal snack frequency (Rugg-Gunn, *et al*., 1984). In addition, because they did not present the data regarding other categories, the existence of a dose-response relationship cannot be determined from a review of the findings. The results of a recent observational study of 2,058 Japanese children aged 3 years who participated in the Fukuoka Child Health Study (Tanaka, Miyake, & Sasaki, 2010) suggest no association between hard cheese intake and the prevalence of dental caries when the results are adjusted for sex, tooth brushing frequency, use of fluoride, between-meal snack frequency, maternal smoking during pregnancy, environmental tobacco smoke exposure at home, and paternal and maternal education levels (Tanaka, Miyake, & Sasaki, 2010). Therefore, the evidence that hard cheese intake has a protective effect on dental caries development in children is scarce.

The evidence suggesting the protective effects of hard cheese intake on dental caries development in adults is also scarce. In a study of the association between both root and coronal caries development and hard cheese intake in an aging population in the United States (Papas, Joshi, Palmer, Giunta, & Dwyer, 1995), Papas *et al*. found that high intake of cheese was negatively associated with caries development, independent of sugar consumption. However, they focused only on the lower quartile of adults with root caries and filled surfaces (DFS)/100 teeth (N = 13) and the upper quartile of adults with root
DFS/100 teeth (N = 16) (Papas, et al., 1995). Therefore, the evidence regarding a linear relationship between the frequency of cheese intake and dental caries development in adults is weak.

In summary, the evidence regarding the preventive effects of hard cheese intake on dental caries development is weak and scarce in both children and aging adults. Further studies must examine this relationship using a prospective design, larger sample size, and adjusted with confounder.

2.3 Dietary Fiber Intake

According to the WHO report, intake of dietary fiber is categorized as a possibly preventive factor in decreasing caries development (Moynihan, 2005). In a survey of the association between dietary fiber and dental experience in 12- and 13-year-old participants (N = 592) in South Korea, Kwon et al. examined (Kwon et al., 1997) the effect of nutrient intake on dental caries development by logistic regression analysis while controlling for other variables such as sex, pit and fissure retentiveness, resazurin disk test results, and intake of other dietary factors (Kwon, et al., 1997). They found that both total caries development and occlusal caries development are significantly negatively correlated with the amount of daily dietary fiber intake (Kwon, et al., 1997). However, stronger evidence of the association between dietary fiber intake and caries development, ideally from a prospective cohort study, is required to confirm this correlation.

2.4 Dietary Patterns

We reviewed the associations between dietary intake of individual foods or nutrients and dental caries. However, Hu et al. pointed out that the results of such analysis can be difficult to interpret because people do not consume nutrients in isolation; hence, strong correlations between various foods and nutrients may be identified (Hu, 2002). In contrast, the collinearity of nutrients or foods can be an advantage in dietary pattern analysis because patterns are characterized on the basis of habitual food use (Hu, 2002). In addition, dietary interventions may be easier to implement and more comprehensive when initiated as changes in the overall dietary pattern (Hu, 2002).

<table>
<thead>
<tr>
<th>Component</th>
<th>Examples</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient</td>
<td>Carbohydrates, protein, fat, vitamin, etc.</td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td>Whole grains, dairy, fruits, vegetables, beans, etc.</td>
<td></td>
</tr>
<tr>
<td>Dietary pattern</td>
<td>“The Mediterranean diet,” “the prudent diet,” “the Dietary Approach to Stop Hypertension (DASH),” a “plant-based diet,” a “vegetarian diet,” etc.</td>
<td>Closer to real-world pattern of combined consumption of nutrients and foods, allowing for investigation of their synergetic effects</td>
</tr>
</tbody>
</table>

Table 2: Level of exposure in nutritional epidemiology

Using data from the US Third National Health and Nutrition Examination Survey (NHANES III) Nunn et al. attempted to clarify the relationship between dietary patterns and caries experience (Nunn et al., 2009). When they examined the relationship between dietary quality as measured by the Healthy Eating Index (HEI) and the prevalence of early childhood caries (ECC) in 2- to 5-year-old children (N = 3,912), they found that children with the best dietary practices were 44% less likely to exhibit severe
When children are diagnosed with ECC, they generally have worse dietary practices than children with worst dietary practices when the results were adjusted by demographic and behavioral characteristics (Nunn et al., 2009). A healthy diet has also been linked to improvements in conditions such as hypertension (Chobanian et al., 2003), diabetes (Alhazmi et al., 2012), cardiovascular disease (Mente, de Koning, Shannon, & Anand, 2009; Yang et al., 2012), and cancer (Doll & Peto, 1981; Kushi et al., 2012; Palacios, Joshipura, & Willett, 2009). Use of an approach analyzing dietary patterns may allow for clarification of the associations between dietary intake and development of dental caries as well as other chronic diseases. As the dietary advice provided regarding general development and well-being needs to be integrated into oral health counseling (Nunn, et al., 2009), further studies are needed to clarify the relationship between dietary patterns and dental caries.

2.5 Summary of Evidence Regarding Diet and Caries

In summary, this section reviewed the evidence regarding the association between caries development and diet, nutrition, and dietary patterns. Except for the amount and frequency of intake of sugars, little evidence exists based on which recommendations for the intake of particular foods or use of dietary patterns can be made to prevent caries development. Further research using a well-designed epidemiological research design and a dietary pattern-level approach that approximates “real-world” dietary patterns is required. Also, since caries is multifactorial disease (Brathall D, et al., 2005), further research on interaction between dietary factors and other factors is needed.

3 The Practice-based Research Network: A New Research Model

3.1 Practice-based Research

Practice-based research is a form of research conducted in clinical practices by practitioners and their staff that is designed to answer the questions that clinicians face in the routine care of their patients (Kakudate N, in press). Practice-based research holds great potential for answering clinical questions and expediting the translation of research findings into clinical practice. In conducting such research, the study of PBRNs offers unique advantages in fostering both research and quality improvement and information sharing among practitioners (Gilbert GH. & for the DPBRN Collaborative Group, 2009).

3.2 Dental Practice-based Research Networks

Since 2000, the Agency for Healthcare Research and Quality (AHRQ) has devoted funding to support primary care PBRNs in the United States. Currently, more than 150 PBRNs other than dental networks are operating in the United States (AHRQ Website). In the dental research area, the National Institute for Dental and Craniofacial Research (NIDCR) has funded 3 dental PBRNs in the United States since 2005 with approximately $75 million: the Dental Practice-Based Research Network (DPBRN), Practitioners Engaged in Applied Research and Learning PEARL (PEARL), and the Northwest Practice-based Research Collaborative in Evidence-based Dentistry (PRECEDENT). In 2012, the NIDCR decided to provide a new grant that consolidates its dental practice-based research network. Upon receiving funding of approximately $66.8 million, the DPBRN established the National Dental Practice-Based Research Network (the National Dental PBRN) (National Dental PBRN Website), which has been headquartered at the University of Alabama at the Birmingham School of Dentistry for 7 years. According to its website, the National Dental PBRN plans to expand the number of participating practitioners to 5,000 and welcomes
the greater participation of practitioners in the various dental subspecialties to develop innovative, low-cost techniques to improve the oral health of all Americans (National Dental PBRN Website). Since 2005, the National Dental PBRN has conducted more than 20 research studies, generating more than 70 peer-reviewed journal articles on topics ranging from preventive and restorative dentistry to temporomandibular muscle and joint disorders.

In 2010, we established the Dental PBRN Japan (JDPBRN; Kakudate N, in press; Kakudate et al., 2012; Dental PBRN Japan Website). Currently, the only network in an Asian country, our network has been acknowledged by the US AHRQ as an international network. The aims of the JDPBRN include the following: 1) building research networks in which dental practitioners are the main actors, 2) sharing information on clinical research that will have a beneficial impact on routine dental practice, 3) participating in international collaborative research and presenting evidence globally, 4) enabling dental professionals to participate in clinical studies to solve their clinical questions, 5) changing dental professionals' views of their daily dental practice and making their practice more interesting, and 6) contributing to the overall health of patients globally by improving the quality of dental practice (Kakudate N, in press). The JDPBRN is a consortium of dental practices with a broad representation of practice types, treatment philosophies, and patient populations that share the DPBRN’s mission (Gilbert et al., 2008) that is now called the National Dental PBRN (National Dental PBRN Website). The network regions of the JDPBRN represent all 7 districts in Japan (Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku-Shikoku, and Kyushu). In 2011, we initiated the first international collaborative study with the US National Dental PBRN entitled “Assessment of Caries Diagnosis and Caries Treatment.” Our previous research results had revealed country-based variations in the proportion of dentists who indicated surgical intervention in patients at high risk of caries development when the interproximal cavity was located within the enamel. Specifically, we found that the proportion of dentists who indicated surgical intervention in the enamel lesions was as follows: Scandinavia, 21%; the United States, 75%; and Japan, 74%. Thus, most JDPBRN dentists indicated that they would restore lesions within the enamel in individuals at high risk of caries. As a first step to improve clinical decision-making, the results of our studies should be reported to the dentists for the purpose of self-assessment of their daily dental practice. Comparison of dental practice patterns will also promote the assessment of each country’s dental health care system and dental education.

Through these research activities, we aim to achieve the following goals: 1) contribute to evidence construction by collaboration with dental clinicians and clinical epidemiologists, 2) improve health care system and policies, 3) create a community of clinicians with a research inclination, and 4) establish a new style of continuing education with the objectives of self-assessment of individual practices and presentation of updates regarding the latest dental information. We anticipate that the achievement of these goals will lead to dietary behavioral modification among the clinicians and improvements in the quality of dental care using feedback from the research results.

### 3.3 Research Steps in Dental Practice-based Research Networks

The PBRN is a new model of epidemiological research. Figure 1 shows that the following steps were used in introducing the research steps in the Dental PBRN in Japan: 1) proposal of a research question based on dental practice; 2) preparation of a protocol and application for approval from the Ethical Review Board; 3) officially beginning data collection within the entire network upon approval of the Ethical Review Board; 4) obtaining of data collected from patients or medical records from each dental clinic for data analysis by the Data Analysis Staff of Research Committee of the JDPBRN; 5) upon completion of
data analysis, collection of the results for presentation at conferences at local, national, or international scientific societies by the principal investigator (PI) or the writing of papers by the PI for eventual publication; and 6) presentation of the results to the network members for improving their daily dental practice. By completing these steps, research data are produced that each member can compare with data from his or her own clinic to develop routine practice, which will generate additional ideas for further research as part of a research cycle.

Figure 1: JDPBRN Research Cycle (http://www.dentalpbrn.jp/category/1445790.html)

4 Practice Patterns Regarding Dental Caries Prevention and Dietary Counseling

This section provides an overview of the evidence regarding the practice patterns and practitioner’s overall perceptions of dental caries prevention as well as dietary counseling based on the new PBRN research model.

4.1 Practice Patterns in Dental Caries Prevention

Dentists’ practice patterns and perceptions regarding caries prevention and dietary counseling and the factors that affect these patterns remain unclear. Fortunately, the recent establishment of the JDPBRN created an opportunity to conduct international comparisons of these patterns and perceptions. To assess dentists’ perceptions of the importance of diet and their practice patterns regarding dietary counseling as well as collect patient, practice, and dentist background data, we conducted a cross-sectional survey in Japan between May 2011 and February 2012 (Kakudate, *et al.*, 2012). We used the same questionnaire as that used in the US DPBRN Study, “Assessment of Caries Diagnosis and Caries Treatment” (Gordan *et al.*, 2009), and the DPBRN Enrollment Questionnaire (Makhija *et al.*, 2009). Table 3 shows the variables examined and the questionnaire items used to collect data regarding the variables.
Variable | Questionnaire item
--- | ---
Prevalence of preventive dentistry | What percentage of patient contact time do you (not your hygienist or other office staff) spend performing prevention-related care (i.e., sealant adhesion, periodic and hygiene examination, diagnostic procedures, and other preventive dentistry procedures)?
Perception of preventive dentistry | How strongly do you agree with the following statement: “A dentist's assessment of caries risk for an individual patient can predict whether or not that patient develops new caries in the future”? (1) strongly disagree, (2) somewhat disagree, (3) neither agree nor disagree, (4) somewhat agree, (5) strongly agree
Factors associated with promoting preventive dentistry | (1) dentists’ individual characteristics, (2) practice setting, (3) patients’ characteristics, (4) procedure-related characteristics
Prevalence of dietary counseling | What is the percentage of patients to whom you or your staff provided dietary counseling at some time?
Perception of dietary counseling | For patients aged more than 18 years, how important is consideration of diet when you decide on a treatment plan? (1) not at all important, (2) slightly important, (3) moderately important, (4) very important, (5) extremely important
Factors associated with promoting dietary counseling | (1) dentists’ individual characteristics, (2) practice setting, (3) patients’ characteristics, (4) procedure-related characteristics

Table 3: Variables examined and questionnaire items used to collect data in the JDPBRN study

4.2 Practice Patterns Regarding Dental Caries Prevention

We conducted research to (1) clarify dentists’ practice patterns regarding caries-preventive dentistry, (2) clarify dentists’ perceptions of caries-preventive dentistry, and (3) test the hypothesis that certain dentists’ characteristics are associated with these practice patterns (Yokoyama et al., 2013a). According to the study results, 72 (38%) participants reported that they provide individualized caries prevention to 50% or more of their patients (“more preventive group”). Overall, the participants reported that they spend 10% of daily practice time on prevention-related care. In a survey using the same questionnaire by the US DPBRN, 52% of patients reported receiving individualized caries prevention (Gordan et al., 2011; Riley et al., 2011). The results of this study suggest that dentists in the US DPBRN (52%) and JDPBRN (41.3%) have similar tendencies in providing individualized caries prevention, but the proportion of those who do so is lower in Japan than that in the United States. Additionally, they revealed that Japanese dentists spend 10% of their daily practice time on prevention-related care, a percentage that is lower than that reported among Northern European dentists. Specifically, a previous study conducted in Norway reported that the mean percentage of time devoted to caries prevention is 16.6% of the total treatment time (dentists who did not treat adult patients were excluded; Haugejorden & Nielsen, 1987) and 22% of the total time for pediatric patients (Wang & Aspelund, 2010).

In Denmark, Iceland, and Norway, providing caries prevention treatment constitutes 18–50% of the dentist’s total time in providing dental care to children and adolescents (Wang, Kalletstal, Petersen, & Arnadottir, 1998). In the United States, the average percentage of total time that general practitioners spend performing preventive procedures increased from 9.4% in 1981 to 12.4% in 1993 (Brown & Lazar, 1998). The lower percentage of time devoted to preventive treatment in Japan may be due to differences between the health care systems of Northern Europe and Japan. In Finland, all inhabitants aged less than
19 years have been entitled to free comprehensive public dental care since 1999, resulting in a utilization rate of approximately 95% (Helminen & Vehkalahti, 2003). In contrast, as the Japanese dental insurance system mainly covers dental treatment (Miyazaki & Morimoto, 1996), the percentage of time spent on providing preventive treatment in Japan might be restricted for economic reasons.

The majority of participants (67%) in our study agreed that performing caries risk assessment is effective for prediction of future caries increment (Yokoyama et al., 2013a). This percentage is consistent with those reported by previous studies, including a study by the US DPBRN using the same questionnaire, which reported that 77% of dentists agree with the effectiveness of caries risk assessment. The results of multiple logistic regression analysis suggest that following variables are associated with whether or not dentists provide individualized caries prevention to 50% or more of their patients (Yokoyama et al., 2013a). Specifically, we found that the percentage of patients interested in caries prevention and the percentage of patients who receive hygiene instruction are significantly associated with a high percentage of patients who receive individualized caries prevention. Our study clarified that a high percentage of patients with a positive perception of preventive dentistry (as measured by the percentage interested in caries prevention) and a high percentage who receive hygiene instruction in a practice are associated with the use of individualized caries prevention by a higher percentage of patients. In a study using the same questionnaire, the US DPBRN found that dentists’ individual characteristics, practice settings, and dental procedures are associated with providing individualized caries prevention to a greater percentage of patients. These findings concur with those of Brennan et al., who noted that dentists’ individual characteristics, dentists’ practice settings, and patient characteristics influence the pattern of preventive care delivered (Brennan & Spencer, 2005). Our model also revealed that dentists’ individual characteristics, their practice settings, the dental procedures that they perform, and their perceptions of their patients’ preference for preventive care are more strongly related to the pattern of preventive care delivered than those factors. A previous systematic review noted that potential barriers to adherence to physicians’ guidelines included dentists’ and patients’ preferences (Cabana et al., 1999; Cochrane et al., 2007). As Cabana et al. noted, potential barriers to adherence to physicians’ guidelines vary according to the topic (Cabana, et al., 1999), and it is possible that dentists’ ratings of patient preferences are strongly related to the practice of preventive dentistry.

We also identified substantial variation in dentists’ practice patterns regarding caries preventive dentistry in our study population. Specifically, we found that the provision of individualized caries prevention is significantly related to a dentist’s provision of other preventive services and to a high percentage of patients interested in prevention, but not to a dentist’s beliefs regarding the effectiveness of caries risk assessment.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Summary</th>
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<tbody>
<tr>
<td>Prevalence of preventive dentistry</td>
<td>1) 38% of dentists surveyed (N = 72) reported providing individualized caries prevention care to 50% or more of their patients. 2) The dentists surveyed spend a mean of 10% of the total daily practice time in providing prevention-related care.</td>
</tr>
<tr>
<td>Perception of preventive dentistry</td>
<td>Among dentists, 67% agree that caries risk assessment is effective.</td>
</tr>
<tr>
<td>Factors associated with promoting preventive dentistry</td>
<td>1) Percentage of dental patients interested in receiving caries prevention care 2) Percentage of dental patients who receive hygiene instruction</td>
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Table 4: Summary of evidence (Yokoyama, et al., 2013a)
4.3 Practice Patterns in Dietary Counseling

Previous studies have provided evidence that one-to-one dietary interventions in the dental setting can change the dietary behavior of practitioners and patients (Harris, et al., 2012). In accordance, the American Dietetic Association recommends collaboration between dieticians and dental professionals for oral health promotion and disease prevention and intervention (Touger-Decker & Mobley, 2007). Kakudate et al. showed that administering dietary counseling is significantly associated with appropriate interproximal enamel surgical intervention: specifically, that dentists who provide dietary counseling tend not to intervene surgically into enamel carious lesions, an approach that is consistent with evidence-based dental treatment (Kakudate, et al., 2012). Although Kelly et al. reported that few dentists or other dental professionals conduct dietary counseling as a key component of regular patient care (Kelly & Moynihan, 2008), dentists’ dietary perceptions and practice patterns regarding dietary counseling remain unclear.

To clarify Japanese dentists’ perceptions and practices, we conducted a cross-sectional survey of the JDPBRN (Yokoyama, et al., 2013b) to identify dentists’ practice patterns regarding dietary counseling, dentists’ perceptions of dietary counseling, and characteristics associated with dentists’ provision of dietary counseling. We found that the majority of the participants (n = 116, 63%) categorized into “more important” group when they decide on a caries treatment plan. However, less than half (n = 56, 48%) who indicated that diet is “more important” reported that they provide dietary counseling to more than 20% of their patients.

The proportion of Japanese dentists who reported placing high value on the importance of diet when deciding on a treatment plan (63%) in our study is consistent with that found in previous studies. According to the results of a study conducted by the US DPBRN using the same questionnaire, 67% of male and 72% of female dentists agree that consideration of a patient’s diet is very or extremely important when deciding on a treatment plan (Riley, Gordan, Rouisse, McClelland, & Gilbert, 2011). In a United Kingdom study, Kelly et al. noted that 66% of British dentists agree that nutrition plays an important role in the maintenance of periodontal health (Kelly & Moynihan, 2008). These studies revealed that over 60% of dentists in the United States, the United Kingdom, and Japan recognize the importance of diet.

However, only about 20% of patients would receive diet counseling in this study (Yokoyama, et al., 2013b). This low rate of dietary counseling practice patterns in dental clinics. This low percentage is consistent with that reported by other studies, including a study conducted by Kelly et al., which found that only 14% of dentists or other dental professionals provided dietary advice as a regular part of patient care (Kelly & Moynihan, 2008). In accordance, Touger-Decker et al. reported that perceived needs for nutrition education in dental school are high, with most respondents in their study indicating a need for graduates of dental school programs to know how and when to conduct a nutritional assessment (Touger-Decker, Barracato, & O'Sullivan-Maillet, 2001). These findings indicate that increasing the administration of dietary counseling in dental settings depends on the provision of appropriate education to dentists.

The results of multiple logistic regression analysis in our study suggest that several variables are associated with a dentist’s tendency to provide dietary counseling (Yokoyama, et al., 2013b). Specifically, the sex of the dentist, the level of practice activity (i.e., the dentist’s “busyness”), whether the dentist performs caries risk assessment, the perceptions of the dentist regarding patient interest in preventive programs, the percentage of the dentist’s patients interested in caries prevention, and the percentage of the dentist’s patients receiving blood pressure screening were all found to be significantly associated with providing dietary counseling. Previous studies reported that lack of willingness of a patient to undergo screening, the costs of screening in term of money and time, and the liability associated with screening
are perceived barriers to the performance of medical screening in dental practices (Greenberg, Glick, Frantsve-Hawley, & Kantor, 2010). In our study, over half of the participants (51%, n = 96) reported that they considered >25% of their patients to be interested in participating in preventive programs. However, a previous study of patient attitudes toward preventive programs reported that the majority of patients expressed willingness to undergo screening for heart disease, high blood pressure, and diabetes by a dentist (Greenberg, Kantor, Jiang, & Glick, 2012). Increasing understanding of the role of preventive care in dental practice and improving its provision requires providing education to both patients and dentists. It also requires gaining a better understanding of patients’ and dentists’ agreement regarding the need for communication of preventive care, an issue that should be further explored (Riley et al., 2012).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence of dietary counseling</td>
<td>21% of patients receive dietary counseling</td>
</tr>
<tr>
<td>Perception of dietary counseling</td>
<td>63% agree that dietary counseling is important</td>
</tr>
</tbody>
</table>
| Factors associated with promoting dietary counseling | 1) Female sex  
3) Percentage of patients interested in caries prevention  
4) Percentage of patients who undergo caries risk assessment  
5) Percentage of patients who undergo blood pressure screening |

**Table 5:** Summary of evidence (Yokoyama, et al., 2013b)

### 4.4 Summary

Studies using the new Dental PBRN model have revealed that more than 60% of the dentists surveyed reported that the provision of both dental preventive care and dietary counseling is important. However, a low percentage of the same dentists also reported actually providing dental preventive care and dietary counseling in their practice. The results of the present study indicate that this discordance between dentists’ perceptions of the importance of providing preventive care and their actual provision of preventive care is related to whether they believe that their patients are interested in caries prevention. To increase patients’ interest in caries prevention, well-designed studies that can collect strong evidence regarding the factors affecting caries prevention, such as diet, are needed.

### 5 Conclusions

Our review of the evidence of a link between dietary intake and dental caries development revealed that few observational studies have explored this association. To fill this research gap, we need well-designed prospective studies that can investigate this link and provide strong evidence of its existence or lack thereof. Our study and previous studies exploring practice patterns in dental caries prevention and dietary counseling in dental clinics also suggest that although most dentists are interested in providing preventive care and/or dietary counseling, relatively few do so in practice.

Our review also suggests a continuing deficiency of evidence regarding the effect of dietary factors on dental caries development. Overcoming this deficiency requires nutritional epidemiology research to provide findings that can promote provision of dietary counseling in dental clinics. Such research should take the form of practice-based research, a new epidemiology study model that collects real-world data,
using the Dental PBRN model. Use of the Dental PBRN model has been found to be an effective means of exploring the evidence and producing feedback that can be rapidly and effectively disseminated throughout practitioner networks. This new research model has great potential to change practice patterns and the provision of health guidance in dental settings. As such, the development of clinical practice guidelines based on evidence obtained from practice-based research in dental settings is expected in the future.

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