ABSTRACT

Title of Thesis: Mothers' Taste Perception and their Preschool Children's Dental Caries Experience

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Purpose: The main purpose of this study was to find out the overall caries experience of the preschool children among mothers of various taste sensitivities to the bitter taste of 6-n-propylthiouracil (PROP). Additionally, the effects of maternal demographic data, living conditions, children's oral hygiene practices and mutans streptococci levels on the association between mothers' taste and dental caries of children were investigated.

Methods: A total of 60 child-mother pairs, attending the pediatric dental clinic at the University of Maryland, matched the inclusion criteria: healthy children, aged 2-3 years old, and their mothers as primary caregivers. Only 38 mothers who were identified as supertasters or non-tasters, based on their taste sensitivity to PROP test, were selected. PROP supertasters express the lowest acceptance for strong bitter and sweet tastes while PROP non-tasters express the highest acceptance for strong bitter and sweet tastes. Data about maternal demographic and oral hygiene practices of the children were obtained by orally administered questionnaire. Children received a clinical examination to determine dental caries prevalence as well as were tested for mutans streptococci (MS) levels.

Results: Among 38 child-mother pairs, 20 mothers were supertasters (aversion to sugars) and 18 mothers were non-tasters (preference of sugars). Children of non-taster mothers were found to have significantly higher prevalence of dental caries and mean dmfs of maxillary anterior teeth than those of supertaster mothers ($p<0.05$). If grandparents of a child from non-taster mothers reportedly lived in the same household, the child’s dmfs score was increased (p=0.005). High consumption of sugary food and mothers’ reportedly having caries were significantly associated with increased dmfs in children (p=0.037, p=0.003 respectively).

Conclusion: The prevalence of dental caries in 2-3 years old children was significantly higher in the preschool children of non-taster mothers than those of supertaster mothers. Other dental caries risk factors for those children included mothers’ reported dental caries experience, grandparents living in family, and high consumption of sugars by the child.

Mothers' Taste Perception and their Preschool Children's Dental Caries Experience

by
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INTRODUCTION

The oral health of preschool children improved considerably in most industrialized countries over the past decades. However, dental caries remains the most common chronic infectious disease of childhood, five times more common than asthma, and affecting a considerable proportion of young children.[1] In 2008, a Progress Review of Healthy People 2010 demonstrated that the dental caries prevalence among children 2-4 years of age has increased from 18% in 1988–1994 to 24% in 1999–2004.[2] In comparison, the dental caries prevalence has declined from 61% to 56% among children 15 years of age, and has stayed relatively the same (52% to 53%) for children 6-8 years of age. The increased dental caries prevalence in preschool children is a cause for major concern due to the negative impact of the disease on the child, family, and community.

Early childhood caries (ECC) is a major health problem world-wide and affects about 28% of US children.[3] It is defined as the "presence of one or more decayed (noncavitated or cavitated), missing (due to dental caries), or filled tooth surfaces in any primary tooth" in children less than 71 months of age.[4] Severe Early Childhood Caries (S-ECC) refers to a more progressive and acute pattern of childhood dental caries, and the term was developed to identify the children with the highest level of disease.[5] The term "severe early childhood caries" (S-ECC) can be used to describe the presence of any smooth surface dental caries in a child younger than 3 years of age. S-ECC can also apply to children ages 3 to 5 who have "1 or more cavitated, missing (due dental to caries), or filled smooth surfaces in primary maxillary anterior teeth or a decayed, missing, or filled score of ≥4 (age 3), ≥5 (age 4), or ≥6 (age 5)".[5] Children with S-ECC are those who are more likely to present with pain, chewing difficulties, speech problems, general health disorders and psychological problems.[6,7] Furthermore, children with severe dental caries have more treatment need, difficulty in accessing oral health care and may require hospital care to treat other advanced oral health needs.[6,8] Treatment of early childhood caries also is expensive. It often requires an extensive restorative treatment and extraction of teeth at an early age with general anesthesia or deep sedation because such young children lack the ability to cope with the procedures. The cost to treat a child with two to five lesions is estimated to be $408 and $1,725 for those with 16-20 lesions.[9] Treatment under general anesthesia may add between $1,500 to $6,000 to the cost of the dental care.[9,10]

The development of dental caries results from critical interactions between a susceptible tooth surface, oral bacteria, and fermentable carbohydrates. In young children, bacterial flora and host defense systems are in the process of being developed, tooth surfaces are newly erupted and may show hypoplastic defects, and their parents must negotiate the dietary transition through breast/bottle feeding, first solids and childhood tastes.[11] Thus it is thought that there may be unique risk factors for dental caries in infants and young children.[12] There are numerous risk factors significantly related to early childhood caries.[11] Risk factors such as past caries experience, salivary counts of streptococcus mutans (MS), socioeconomic factors, and the frequency of sugar intake have been evaluated to identify children at high risk of dental caries.[13,14,15] The first sign of the dental caries process is a white, chalky appearance of the tooth. This “white spot lesion” can progress to cavitation of the enamel surface with the continuous presence of an unfavorable environment such as a constant presence of sugar, no fluoride, or reduced salivary flow. The presence of white spot lesions on enamel smooth surfaces is considered equivalent to a cavitated lesion when determining dental caries risk in young children.[16] A systematic review of the literature on caries risk indicators by the American Academy of Pediatric Dentistry (AAPD) concluded that previous dental caries experience was the strongest predictor of dental caries in primary teeth. One study by O'Sullivan and Tinanoff demonstrated that three-year-olds with dental caries will have significantly more decay by the age of five years compared to dental caries free three-year-olds.[17] In addition, a longitudinal study has shown that dental caries in posterior primary teeth may be a strong predictor for dental caries in permanent teeth.[18] It also has found that children from the ECC group had the highest number of new carious lesions per year after seven to ten years.[18]

Other factors may play a role in the dental caries process such as social, cultural, and behavioral factors. In order to represent the multi-factorial nature of the disease, Fisher-Owens et al. has created a conceptual model of the many influences on a child's oral health.[19] Surrounding the original model triad of host, substrate, and microflora, are three levels of influence: child, family, and community. Child-level influences include child biological and genetic endowment, dental insurance, and the use of dental care.[19] Family-level influences include health status of parents, socioeconomic status, culture, and social support.[19] Finally, community-level influences include community oral health environment as well as health and dental care system characteristics.[19] A time factor is also included to represent the changing nature of a child's oral health status. For example, as a child enters adolescence or the teenage years, diet or oral hygiene can change leaving the child at an increased risk of dental caries.

Many studies have demonstrated that family income and race/ethnicity are also major factors affecting the dental caries rate.[2,3,20] From US epidemiologic studies the greatest amount of tooth decay is found in Mexican-American children, and twice as many children from low-income families had dental caries as those from high-income families.[3] Other studies have found that children from a low socioeconomic status and whose parents are poorly educated are also at a greater risk of decay.[20-25] In a study of disparities in oral health among children 2-4 years old, Edelstein concluded that tooth decay is more prevalent in Hispanic and African-American children, children of a low socioeconomic status, and children of parents having less than a high school education.[26] The extent of decay and the prevalence of untreated decay are also correlated with the minority status. A higher percentage of minority children, children of a low socioeconomic status, and children of parents having less than a high school education also have been shown to have unmet dental needs.[26]

Mutans streptococci (MS) have been implicated as the principal bacterial component responsible for dental caries in humans and the key to the understanding of caries in preschool children.[27,28] MS are believed to contribute to the dental caries because of their ability to adhere to tooth surfaces, produce copious amounts of acid, and survive and continue the metabolism at low pH conditions.[29] Colonization of the oral cavity with MS in children is generally the result of transmission of these organisms from the child's primary caregiver, usually the mother.[30,31] Li and Caufield found a strong evidence supporting that mothers are the major source of MS in infants. For example, they found homologous MS genotypes in 71% of mother-infant pairs.[31] However, Mitchell and colleagues found an evidence of maternal transmission in only 41% of mother-child pairs.[32] In 2008, Douglas et al. reviewed 46 studies published between 1975 and 2006 that evaluated the role of primary caregivers in the MS colonization of their preschool children.[33] Of these studies: 17 examined the evidence for mothers as the source of MS in their children. Most of these reports showed that over half of the MS isolates found in children were identical to their mothers. They also found that MS can be transmitted from mothers to their children, especially when mothers have high MS levels.[33] Children of mothers having high levels of MS are more likely to exhibit levels of MS corresponding to their mothers' levels [34-36] and often experience a higher dental caries incidence.[35] Maternal factors, such as high levels of MS, poor oral hygiene, low socioeconomic status, and frequent snacking, contribute to this maternal transfer.[33]

It is found that preschool children with high colonization levels of MS have been shown to have a greater risk for new lesions than those children with low levels of MS.[37] Factors which influenced the colonization were the frequent sugar exposure in children and habits that allowed the salivary transfer from mother to infants. In a study by Habibian et al., the researchers demonstrated that they were more likely to find detectable levels of mutans streptococci in children who had not had their teeth brushed by 12 months of age compared to children who had had their teeth brushed.[38] Also, Habibian and colleagues reported finding detectable levels of mutans streptococci in children who ate/drank anything more than 6.7 times a day. Naturally occurring carbohydrates in cow milk, human milk, and sugars added to fruit juice and soda serve as nutrients for the bacteria.[38]

The role of diet as a direct cause of dental caries has been extensively reported. A high daily intake of sugars has been correlated with a high dental caries experience in preschool and school age children.[39] It is well established that the higher and more frequent sugar intake increases the risk of dental caries formation in children.[40,41] Dental caries risk is greatest if sugars are consumed at a high frequency and are in a form that is retained in the mouth for long periods.[15] Sucrose appears to be the most cariogenic sugar, not only because its metabolism produces acid, but also because MS utilize this sugar to produce the extracellular polysaccharide glucan. Glucan polymers are believed to enable MS to both adhere firmly to teeth and to inhibit diffusion properties of plaque.[42]

The carbohydrate concentration of fruit juice ranges from 11g/100ml to more than 16g/100ml, while human milk and formula have 7g/100ml.[43] In a study examining the cariogenicity of different drinks, Bowen and Lawrence found that the highest level of smooth surface dental caries was found in the rodent models that were given cola, 10% sucrose, and 10% honey.[44] In addition, animals fed human milk experienced significantly more smooth surface dental caries compared to those fed cow's milk.[44] The authors also suggested one reason for this difference is because human milk contains 7% lactose while cow milk contains 5% lactose.[44] Also the composition of cow milk differs from that of human milk.[44] The authors concluded that cow's milk had a relatively low cariogenicity. Lim and colleagues found that children who consumed more soft drinks compared to milk or 100% fruit juice were at a higher risk of dental caries.[45] Frequency and modality of consumption are both factors that influence the dental caries rate.[45,46] Thitasomakul and colleagues studied children 9 to 18 months old and concluded that the highest prevalence of dental caries was found in children who had sweet tasting foods and started snacking at 5 months of age, had sugary snacks, had soft drinks, and did not have their teeth brushed daily at 9 months of age.[47]

Excessive juice consumption has been associated with malnutrition, diarrhea, flatulence, and abdominal distention.[43] According to the American academy of Pediatrics (AAP), children 1 to 6 years old should be limited to 4 to 6 oz. per day of fruit juice.[48] The AAP recommends that juice should not be introduced into the diet before 6 months of age, children should only be given water in a bottle or sippy cup when it is not mealtime, children should not be given juice at bedtime, children should be encouraged to eat whole fruits rather than juice, and eat sugary food only at mealtime.[48] Recent research has demonstrated that today's children are getting more sugar-sweetened beverages and 100% fruit juice than needed for a healthy diet.[49] An analysis of the NHANES III, 1988-1994 and the NHANES 1999-2004 found that the per-capita daily caloric contribution from sugar-sweetened beverages and 100% fruit juice across all youth has increased from 242 kcal/day to 270 kcal/day.[49] There was also a statistically significant 3 percent decrease in milk consumption among children 2 to 5 years between 1988-1994 and 1999-2004.[49] The study also found that children 2 to 5 years of age who drank sugar sweetened beverages consumed an average 15.5 oz. per day. Similarly, in the same age group, those who drank 100% juice consumed an average of 10 oz. per day.[49]

The intensity of dental caries in preschool children may be due, in part, to the frequent sugar consumption. The high sugar intake reflects a preference for sweet substances among the majority of children.[41] Pattern of food preferences suggests the existence of innate predisposition toward tastes.[50] In particular, food preference is found to be related to the genetic sensitivity to taste.[51] Differences in a taste receptor gene influence the taste sensitivity of humans, accounting for individual differences in taste preferences and food selection. That means genetic variations in taste perception might contribute to differences in food preferences. Therefore, perceptions of bitterness and sweetness vary depending on one's genes.[51] Recent studies of mammalian bitter taste receptors suggest that the number of distinct receptor genes are about 30.[52] The genetic sensitivity can be measured with a bitter compound 6-n-propylthiouracil (PROP).[53] From birth to old age, the ability to taste compounds that contain an N-C=S group such as phenythiocarbamide (PTC) and its chemical relative propylthiouracil (PROP) is evident in human population.[53-55] PROP is a medication used in the treatment of Graves's disease (hyperthyroidism) and the therapeutic dosage is 150-200 mg daily for adults and 50-150 mg daily for children. However, PROP can be tasted at very low concentration and the filter paper used for taste research contains only approximately 1.6mg of PROP.[56] PTC and PROP are of great interest to taste researchers not only as tools for understanding the genetic transmittance of taste but for gaining insight into the seemingly endless of variation in taste preferences and food habits that exists in the population.[57] Taste blindness to PROP/PTC has been found in virtually all populations around the globe.[57] However, the frequency of non-taster individuals within a population varies markedly by race and ethnicity. The estimated frequency of non-taster individuals among Caucasians is ~30%.[57] Estimated frequencies of non-tasters are generally lower (~10-20%) in populations studies in China, Japan, and sub-Saharan Africa but can exceed 50% in some subgroups studies in India.[58] The reason for this worldwide diversity is unclear. Although these chemicals taste bitter to some, others either cannot taste them or require a high concentration to recognize its presence.

The gene responsible for variation in PTC and PROP sensitivity is TAS2R38 which resides on human chromosome 7.[59] Three single nucleotide polymorphisms of this gene result in three amino acid substitutions at positions P49A, A262V, and V296I and give rise to two common haplotypes, PAV (the taster variant) and AVI (the non-taster variant). PROP sensitive individuals possess one or two dominant alleles (PAV/PAV or PAV/AVI), whereas insensitive individuals are recessive for the trait (AVI/AVI).[59,60] PROP status has been associated with greater perceived intensity of other oral sensations including sweetness,[61] irritation from capsaicin and alcohol,[62,63] and the texture of liquid fats.[63] These observations imply that this trait might serve as an index of general taste ability, an idea that has been suggested previously.[64] This possibility could have broad implications for food selection and nutritional status since numerous studies have reported that PROP tasters express lower liking for sweet taste,[65] salad dressings,[66] sweetened milks,[63] pungent foods,[67] and alcoholic beverages.[68] The relationship between the ability to taste PROP and the perception and liking of bitter and other strong-tasting foods is complex and not completely understood.[63] Moreover, linking PROP status with food selection, dietary patterns, and ultimately to nutritional outcomes may be a difficult task because human eating is a complex behavior with multiple determinants. These determinants include, but are not limited to, age, gender, ethnicity and culture, prior experiences with foods, personality traits, and attitudes about nutrition, health, and bodyweight.[63]

Taste sensitivity to PROP can be determined by the use of threshold methods. The threshold is defined as the lowest concentration of a test solution that can be distinguished from plain water. Tasters have very low thresholds for PROP (i.e., high sensitivity at low concentrations), whereas non-tasters have higher thresholds (i.e., poor sensitivity at low concentrations).[57] Thus, individuals detecting a strong bitter sensation are defined as PROP supertasters, whereas those who do not detect bitterness are referred to as PROP nontasters.[53,69,70] Supertasting is now known to be a much more general phenomenon than was known before the availability of genotyping for the PROP gene. Supertasters are those individuals who experience more intense oral sensations from a variety of stimuli (taste, oral burn, and oral touch).[69] Anatomical studies have provided clues as to why PROP tasters may be more sensitive to such a broad range of oral stimuli. The taste papillae are the structures that hold and orient the taste buds on the tongue. PROP tasters have both a higher density of taste papillae on the apex of the tongue and more functional taste buds.[69, 71] This might explain the greater sensitivity of PROP tasters to basic tastes such as bitter and sweet. Also, supertasters have the largest number of fungiform papillae, structures that not only house taste buds but also are innervated by nerve fibers mediating oral burn and touch.[69] These sensory and anatomical differences observed between non-tasters and supertasters have allowed identifying the associations between sensory experience, dietary behavior and disease risk.[72]

The taste of sucrose is more intensely sweet to PROP supertasters than to medium tasters and non-tasters, and similar results have been reported for some high-intensity sweeteners such as saccharin and neohesperidin dihydrochalone.[70] The majority of non-tasters like sweet food and preferred strong tasting food products, while the majority of supertasters were sweet dislikers and preferred weak tastes.[73,74] In a similar study done by Hedge and Sharma, they found 80.6% of supertaster children did not prefer sweets and fatty food whereas 73.6% of non-tasters preferred sweets and fatty food. But, only 25% of children who are medium tasters preferred sweets.[75] Adult PROP supertasters also tend to perceive stronger sweetness in saccharine and sucrose.[53,76] Also, Feeney et al. found that non-tasters (NT) had significantly lower perceived sucrose intensity ratings in both adults and children.[77] Thus, non-tasters may have a higher concentration and frequency of sugar intake compared to supertasters or medium tasters and therefore more susceptible to dental caries and overweight.[51] Several studies found that the overall dental caries experience in children was significantly higher for non-tasters than supertasters.[56,74,75,78] Non-tasters have a higher prevalence of coronal dental caries than supertasters, suggesting that food intake is affected by genetically determined differences that may lead to high consumption of sweet food.[56] As a result, PROP test proved to be a useful tool in determining the genetic sensitivity levels of bitter taste and perhaps as a screening tool to identify children at risk of developing dental caries.[75,78]

It has been suggested that early experiences with food may lead to different food preferences, which shape eating behaviors.[79-81] The development of children's food preferences involves a complex interplay of innate, familial and environmental factors, not all of which are likely to promote a healthy and varied diet. Parents may play an important role in shaping their children's eating habits.[81] Parents provide food environments for their children's early experiences with food and eating. The family eating environments include parents' own eating behaviors and child-feeding practices that influence the development of children's eating behaviors.[81] Parental feeding strategies such as restriction, monitoring, and pressure to eat have been shown to alter children's eating patterns but not always in the desired direction.[79] Mothers may play a significant role in the establishment of their children's dietary preferences and patterns of dental health.[82] Therefore, mothers could influence their children via their own preferences which may limit foods offered to the children.[50] In addition, using sugary snacks as rewards has been shown to increase a child's preference for that food.[83]

Maternal attitudes must certainly affect their children indirectly through foods purchased for and served in the household, thereby also influencing the children's exposure, habits and preferences.[84] A recent study of mothers and their infants found that if mothers had poor diet quality (i.e. mother did not eat breakfast and did not eat at least one serving of fruits, vegetables or dairy), their infants were at increased risk for poor diet quality as well.[85] Greater maternal self-reported intake of fruits, vegetables, snacks/desserts and soda were associated with greater variety of fruits, vegetables, snacks/desserts and soda, respectively, offered to their children at 13 months of age.[86] Among pre-school age children 2–6 years old, parental consumption of fruits and vegetables was associated with children’s consumption.[87] Furthermore, Hoerr and colleagues found significant associations between mothers’ and infants’ beverage consumption with, for example, greater maternal soft drinks consumption associated with greater child soft drink consumption at both 24 and 36 months of age.[88] Contento et al. found a relationship between mother's health motivation and the quality of children's diet.[89] There was also a significant relationship between mothers' ratings of the importance of health in food choices and their child's food intake in the Family Diet Study.[84] Likewise, Olivera et al. showed a correlation between mothers' and children' food intakes for most nutrients in preschool children.[90] In addition, mothers tend to feed their children more sweet products, more unhealthy breads and dairy products.[91] Therefore, parental influences, particularly maternal influences, appear to play a role in children's food choice. Knowledge of the mother's taste sensitivity may facilitate the identification of children who are at high risk for developing dental caries.

PURPOSE OF THE PRESENT STUDY

The main purpose of this study is to find out the association between the mothers' taste perception and the dental caries experience of their preschool children. A secondary purpose is to investigate the consequences of mothers' taste perception on mothers' demographic factors, child's MS counts, and oral hygiene practices with dental caries experience of their children.

HYPOTHESES

Null Hypotheses

H0: There is no difference in the overall dental caries experience between the preschool children of supertaster mothers and the preschool children of non-taster mothers.

H0: Preschool children covered by Medicaid insurance from non-taster mothers are at a similar risk of dental caries as children covered by Medicaid insurance from supertaster mothers.

H0: Preschool children from non-taster mothers having high school education or less are at a similar risk of dental caries as children from supertaster mothers.

H0: Preschool children from non-taster mothers having active dental caries are at a similar risk of dental caries as children from supertaster mothers having dental caries.

H0: Preschool children living with their grandparents and non-taster mothers in the same household are at a similar risk of dental caries as children living with their grandparents and supertaster mothers.

H0: Preschool children having high MS level from non-taster mothers are at a similar risk of dental caries as children with the same characteristic but from supertaster mothers.

H0: Preschool children practicing poor oral hygiene from non-taster mothers are at a similar risk of dental caries as children with the same characteristic but from supertaster mothers.

H0: Preschool children frequently consuming sugar containing foods or drinks from non-taster mother are at similar risk of dental caries as children with the same characteristic but from supertaster mothers.

H0: Preschool children frequently consuming sugary drinks at bedtime using bottle or from non-taster mothers are a similar risk of dental caries than children with the same characteristic but from supertaster mothers.

Research Hypotheses

H1: There is a difference in the overall dental caries experience between the preschool children of supertaster mothers and the preschool children of non-taster mothers.

H1: Preschool children covered by Medicaid insurance from non-taster mothers are at a greater risk of dental caries than children covered by Medicaid insurance from supertaster mothers.

H1: Preschool children from non-taster mothers having high school education or less are at greater risk of dental caries than children from supertaster mothers with the same education level.

H1: Preschool children from non-taster mothers having active dental caries are at a greater risk of dental caries than children from supertaster mothers having active dental caries.

H1: Preschool children living with their grandparents and non-taster mothers in the same household are at a greater risk of dental caries than children living with their grandparents and supertaster mothers.

H1: Preschool children having a high MS level from non-taster mothers are at a greater risk of dental caries than children with the same characteristic but from supertaster mothers.

H1: Preschool children practicing poor oral hygiene from non-taster mothers are at a higher risk of dental caries than children with the same characteristic but from supertaster mothers.

H1: Preschool children frequently consuming sugar containing foods or drinks from non-taster mother are at greater risk of dental caries than children with the same characteristic but from supertaster mothers.

H1: Preschool children who frequently consume sugary drinks at bedtime, using a bottle from non-taster mothers are a greater risk of dental caries than children with the same characteristic but from supertaster mothers.

MATERIALS AND METHODS

This study was approved as an expedited review of minimal risk by the University of Maryland Institutional Review Board. Preschool children and their mothers who presented to the pediatric dental clinic at the University of Maryland Baltimore for routine dental care were given the opportunity to participate in the study. Selection was based on the following criteria: children aged two to three years old with ASA physical status I or II, and mothers who are the primary caregivers and their age between 18 to 45 yrs. The research procedures, possible discomforts or risks as well as possible benefits were fully explained. Informed consent and HIPAA forms were obtained from the participant mothers prior to beginning the research procedures.

Population

Sixty child-mother pairs met the selection criteria for the study. Based on the PROP test results, 38 mothers were identified as either supertasters or non-tasters and included in this study. The racial/ethnic background of these children was predominantly African-American. They were mainly living in Baltimore city**. A**n effect size equal to 0.50, a one-tail test, a $p \leq 0.05$, and power equal to 0.81 were used to determine the minimum required sample size (n=17) in each taste group. To calculate the effect size, a difference of one in dmfs was considered important (zero dmfs for supertaster mother and one dmfs unit for non-taster mother).

Questionnaires

A questionnaire was used to collect data on the demographic information of the participant mother including age, ethnicity, occupation, education level, and insurance type, as well as questions regarding her oral health status and the number of other family members (less than 18 yrs.) in the household (Appendix A). Another questionnaire was used to collect data on oral hygiene practices of the child including frequency of tooth brushing, use of fluoridated toothpaste, use of baby bottle and its contents at bedtime, frequency of sugary food and drinks intake and child's dental visits. As an example of those types of questions: “How many times your child brushes his/her teeth per day?”, “Does your child toothpaste contain fluoride?”, and ”Does your child drink from a bottle?” (Appendix B).

Clinical Examination

A single examiner performed a clinical examination of the participant children to determine the presence and absence of decayed, filled, and missing teeth surfaces (dmfs index). The examinations were conducted using mouth mirror and head lamp. No diagnostic radiographs were taken. The subject was placed in a knee to knee exam position with the child's head in the lap of the examiner. The examinations were conducted after the teeth were cleaned with a toothbrush and water. The examiner used direct or indirect vision (mirror) to observe and examine all surfaces of the teeth (Appendix C). Exam was conducted without explorer or compressed air. Incentives were given for the participant children (stickers, prizes, etc). Fluoride varnish applied if the child did not have it in the past 6 months.

Mutans Streptococci (MS) Count:

A pooled plaque specimen was collected prior to the clinical exam from each participant child with a sterile cotton swab rubbing across all dental surfaces of maxillary and mandibular teeth. Then, a swab was placed in 0.5 ml of saline in a screw-capped vial. In the lab, vials containing plaque was dispersed by vortexing for 10 seconds, serially diluted 1:10 in saline and was plated on mitis salivarius kanamycin bacitracin agar (MSKB) for recovery of MS.[91] Dilution and plating were conducted by microbial techniques described by Westergren and Krasse.[92] All inoculated plates were incubated at 37^0C in air containing 5% carbon dioxide for 72 hours. After incubation, colony forming units (CFU) on each plate were enumerated. Counts were conducted by one investigator who has no knowledge of the clinical status of the subject. The densities of the resulting MS colonies were assessed by a colony density chart supplied by the manufacturer (Appendix E). MS density was recorded as either 0, 1, 2 or 3. These numbers represent $<10^3$, $\sim10^4$, $\sim10^5$ and $>10^6$ MS/ml saliva.

PROP test

This taste test was carried out on the participating mothers. A small piece of filter paper (3 cm circles of Whatman grade 1 filter paper) containing 1.6mg 6-n-propylthiouracil (PROP) was used. The mothers were instructed to put the whole piece in the mouth and let it get well moistened with saliva. To qualify the intensity of the bitter taste, a scale called the general Labeled Magnitude Scale was used (Appendix D).[93] The scale covers the whole range of sensory intensity and participants rated their taste sensations from (0 to 100). The value categorized the mothers as supertasters when the value was $\geq$60, medium tasters when it was between 12-59, or non-tasters when it was <12. A scaling training form was used before the scale to train the mothers to imagine the strongest sensory intensity in any sensory modality (e.g., strongest pain, looking at the sun, hearing a fire engine go by right by your ear, etc.) and this acted as a standard in the comparison with the bitterness of PROP. That is, given one's understanding of the sensory world, how much more intensity might one experience if the stimulus were increased in a realistic way.

Statistical Analysis

The data from the questionnaires and all forms were entered into SPSS statistics program- version 19. All entries were double-checked for accuracy. The database was only accessible to those directly involved in the study. Descriptive statistics were used to analyze the distribution of the children's age, ethnicity, gender, and insurance type, and their mothers' age, education level, and reported maternal dental caries as well as the presence of their grandparents in the household. Also, descriptive statistics were used to calculate the frequency of daily tooth brushing, use of fluoridated toothpaste, use of baby bottle, daily consumption of sugary food and drinks, and number of dental visits. In addition, they were used to calculate the mean and standard deviation for white spot lesions and decayed, missing, and filled surfaces. Using data from the preschool children of supertaster mothers and the preschool children of non-taster mothers, analysis of variance (ANOVA) was applied to determine the difference in the dental caries experience (dmfs) for all erupted primary teeth and also for the maxillary anterior teeth. Two-way ANOVA was used to compare the dmfs in children of mother's PROP type and mothers' demographic factors, children's oral hygiene factors and MS levels. A p-value of <0.05 was considered statistically significant.

The unadjusted odds ratios were calculated for dental caries prevalence in relation to the main variables in the study, PROP type, mothers' reported dental caries, presence of grandparents, MS count, frequency of sugary food, and drinking sweetened beverages at bedtime. For analysis of the odds ratios, the levels of MS count were $\leq 10^4$ versus $>10^5$ and the levels of sugary food were once or less/day versus twice or more.

RESULTS

The study population

The sample population consisted of 38 healthy preschool children and their primary care mothers. Children's ages ranged from two to three years, of which were 17 boys and were 21 girls. Mothers of those children varied in age between 18 years and 45 years. Among those mothers, eighteen subjects were PROP non-tasters and twenty subjects were PROP supertasters. The sample included twenty-five African Americans, six Whites, three Hispanics, three Asians, and one other race. Twenty nine subjects (76%) were covered by Medicaid insurance. Regarding the educational level of mothers, twenty mothers (52%) were high school graduates or without high school education diplomas, while eighteen mothers (47%) had some college or college diplomas (Table 1).

Twenty five children in this sample (65.7%) reportedly brushed their teeth at least twice a day and only three children reportedly never brushed their teeth. Among children who brushed their teeth, half of them reported the use of fluoridated toothpaste (50%) and the majority of them brushed their teeth with the help of their mothers (71%). Children who had used a baby bottle but stopped using it at age one or earlier were 81.5% of the sample. Only five mothers reported the continuous use of a baby bottle by their children. Almost one-third of the children (28.9%) reportedly consumed sweetened beverages in their baby bottle at bedtime and about half of them (55%) reportedly consumed those beverages more than once a day. Also, fifty percent of the children reportedly consumed sugary food more than once a day. With respect to previous dental visits, thirty-three children reportedly visited a dentist (86.8%). The main reason for the dental visits was professional prophylaxis (84.2%). Only eight children (21%) had dental visits for caries or a toothache. High levels of mutans streptococci (>10^5) were detected in 31.5 % of the children (Table 2).

Table 1. The distribution of demographic factors among children of non-taster mothers and supertaster mothers

Demographic factors	Children,all n=38	Children of non taster mothers n=18	Children of supertaster mothers n=20
Mean mothers' age (SD)	33.5 (6.6)	35.3 (7.8)	32 (5.1)
18-27	17	7	10
28-37	17	7	10
38-45	4	4	0
Mother's education level			
High school/GED or less	20	9	11
Some College/College	18	9	9
Mother's ethnicity (%)			
White	6 (15.7)	4 (22.2)	2 (10.0)
African American	25 (65.7)	11 (61.1)	14 (70.0)
Hispanic	3 (7.9)	1 (5.5)	2 (10.0)
Asian	3 (7.9)	2 (11.1)	1 (5.0)
Others	1 (2.6)	0	1 (5.0)
Mother has dental caries			
Yes	26	15	11
No	12	3	9
Grandparents in household			
Yes	14	6	8
No	24	12	12
Insurance by Medicaid (%)	29 (76.0)	15 (51.7)	14 (48.2)
Child's age			
3 yrs	23	10	13
2 yrs	15	8	7
Child's gender			
Male	17	7	10
Female	21	11	9

Table 2. The distribution of oral hygiene factors and MS levels among children of non-taster mothers and supertaster mothers

Oral hygiene factors	Children,all n=38	Children of non taster mothers n=18	Children of supertaster mothers, n=20
Frequency of toothbrushing			
Never/sometimes	3	2	1
Once/day	10	6	4
Twice or more/day	25	10	15
Use of fluoridated toothpaste			
Yes	19	8	11
No	19	10	9
Help in toothbrushing,yes (%)	27 (71.0)	11 (61.1)	16 (80.0)
Current use of baby bottle (%)	5 (13.0)	3 (16.6)	2 (10.0)
Age stopped baby bottle, ≤1yr(%)	31 (81.5)	13 (72.0)	18 (90.0)
Drinking sweetened beverages at bedtime in baby bottle (%)	11 (28.9)	5 (27.7)	6 (30.0)
Frequency of sugary food			
≤ once/day (%)	19 (50.0)	6 (33.3)	13 (65.0)
> once/day (%)	19 (50.0)	12 (66.6)	7 (35.0)
Frequency of sugary drinks			
≤ once/day (%)	17 (44.7)	7 (38.8)	10 (50.0)
> once/day (%)	21 (55.2)	11 (61.1)	10 (50.0)
Previous dental visits, yes (%)	33 (86.6)	15 (83.3)	18 (90.0)
for cleaning (%)	32 (84.2)	14 (77.7)	18 (90.0)
for cavity or toothache (%)	8 (21.0)	5 (27.7)	3 (15.0)
Mutans streptococci , >10^5 (%)	12 (31.6)	5 (27.7)	7 (35.0)

Dental caries experience of preschool children

Caries experience for all teeth as well as for only the maxillary anterior teeth was evaluated by decayed (ds), missing (ms), and filled (fs) surfaces (dmfs), or teeth (dmft) as well as white spot lesion (WSL). Fifty-five percent (n=21) of the participant children were caries-free (dmfs=0). Of those, 71.4% of children (n=15) had mothers who were supertasters. On the other hand, 45% of children (n=17) had caries (dmfs$\geq$1). Of those, 70.5 % of children (n=12) had mothers who were non-tasters. A statistically significant association was found between mothers PROP taste and dental caries prevalence in their children ($F=7.640$, $p=0.009$). Thirty-three percent of children had smooth-surface dental caries; therefore, they were diagnosed as having S-ECC. Dental caries experience in children from non-taster mothers was more than twice as high as that in children from supertaster mothers (mean=3.94$\pm$5.3 vs. 1.85$\pm$4.0), but this result was not statistically significant ($F=1.88$, $p=0.179$). A statistically significant difference was found when the mean dmfs of the maxillary anterior teeth was calculated for preschool children of non-taster mothers (2.61$\pm$3.5) and those of supertaster mothers (0.70$\pm$1.7, $F=4.71$, $p=0.037$). In addition, there were more white spot lesions in all teeth in the non-taster group (3.72$\pm$3.6) than in the supertaster group (1.75$\pm$3.2, $F=3.11$, $p=0.086$); see Table 3. The distribution of the mean dmft for all maxillary and mandibular teeth in both groups is presented in Figures 1 and 2. Also, the distribution of the mean dmfs of maxillary anterior teeth among the groups is presented in Figure 3.

Table 3. The analysis of variance for ECC, mean (standard deviation) decayed (ds), missing (ms), filled (fs) surfaces (dmfs),or teeth (dmft), and white spot lesions (WSL) among children from non-taster and supertaster mothers.

Variables	PROP type		F	p	Partial Eta squared	Observed power
	Non-taster	Supertaster				
ECC (n) yes no	 12 6	 5 15	7.640	0.009†	0.175	0.767
	Mean (SD)	Mean (SD)	F	p	Partial Eta squared	Observed power
dmfs	3.94 (5.3)	1.85 (4.0)	1.881	0.179	0.050	0.27
ds	3.28 (5.0)	1.35 (3.7)	1.795	0.189	0.047	0.26
ms	0.0	0.0	-	-	-	-
fs	0.67 (1.8)	0.50 (2.0)	0.70	0.793	0.002	0.58
dmft	2.39 (2.2)	1.65 (3.5)	0.563	0.458	0.015	0.11
dmfs of Maxillary Anteriors	2.61 (3.5)	0.70 (1.7)	4.710	0.037†	0.116	0.56
WSL	3.72 (3.6)	1.75 (3.2)	3.119	0.086	0.080	0.41

†significant ($p<0.05$)

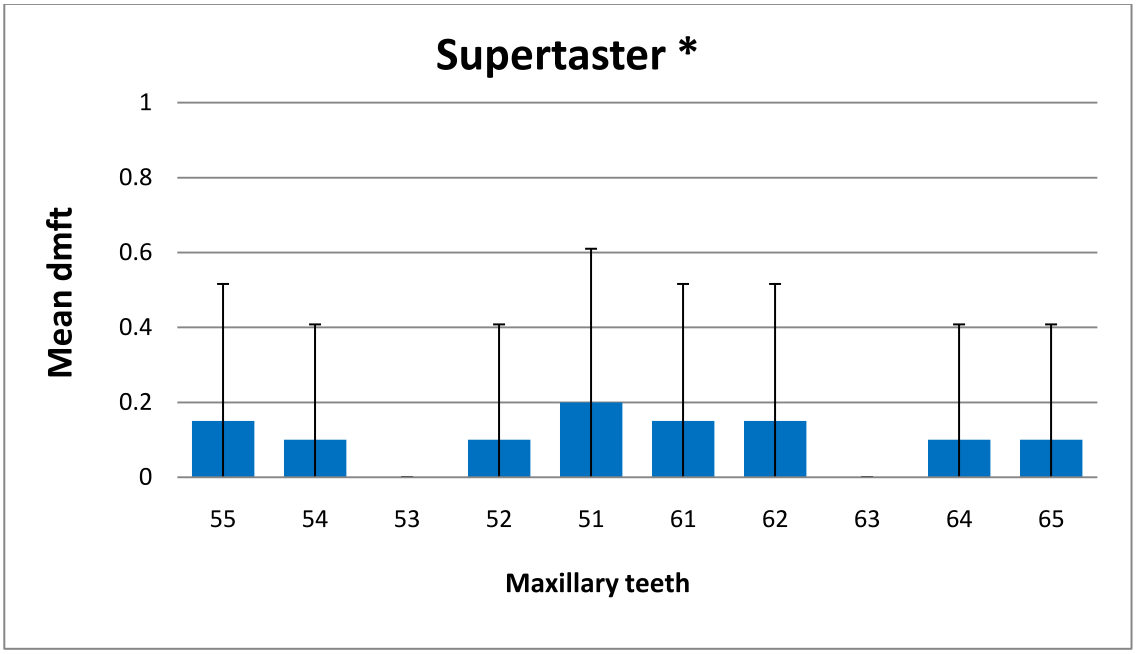


Figure 1a. Mean (± SD) dmft for all maxillary teeth in children of supertaster mothers

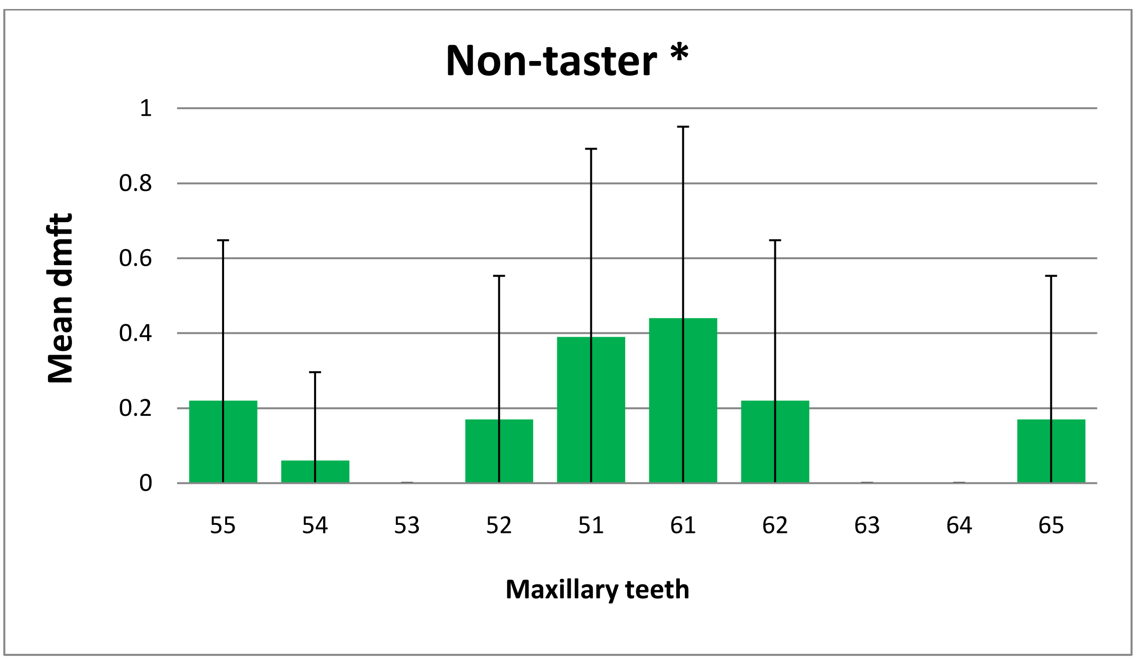


Figure 1b. Mean(± SD) dmft for all maxillary teeth in children of non-taster mothers

* The mean differences between these two groups for each tooth (55-65) were not tested

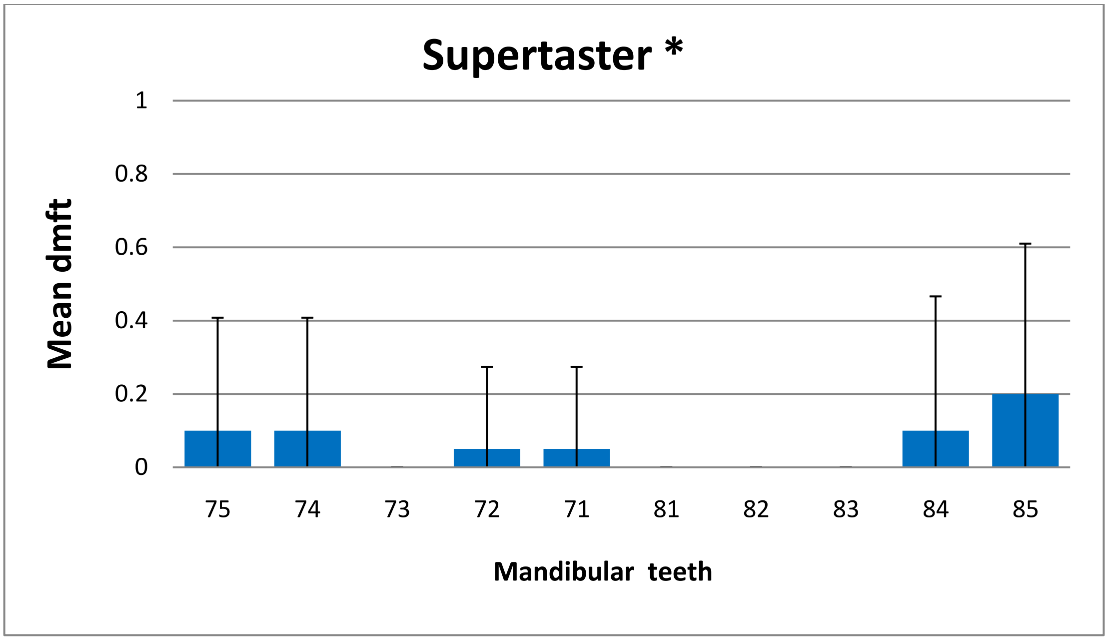


Figure 2a. Mean (+ SD) dmft for all mandibular teeth in children of supertaster mothers

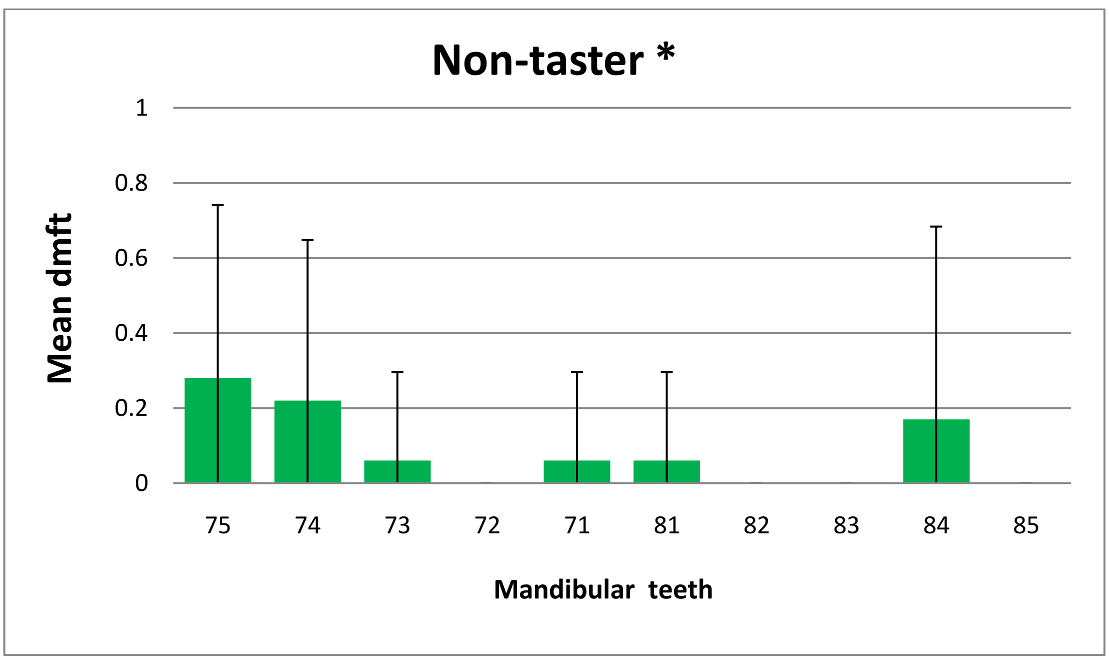


Figure 2b. Mean (+ SD) dmft for all mandibular teeth in children of non-taster mothers

* The mean differences between these two groups for each tooth (75-85) were not tested

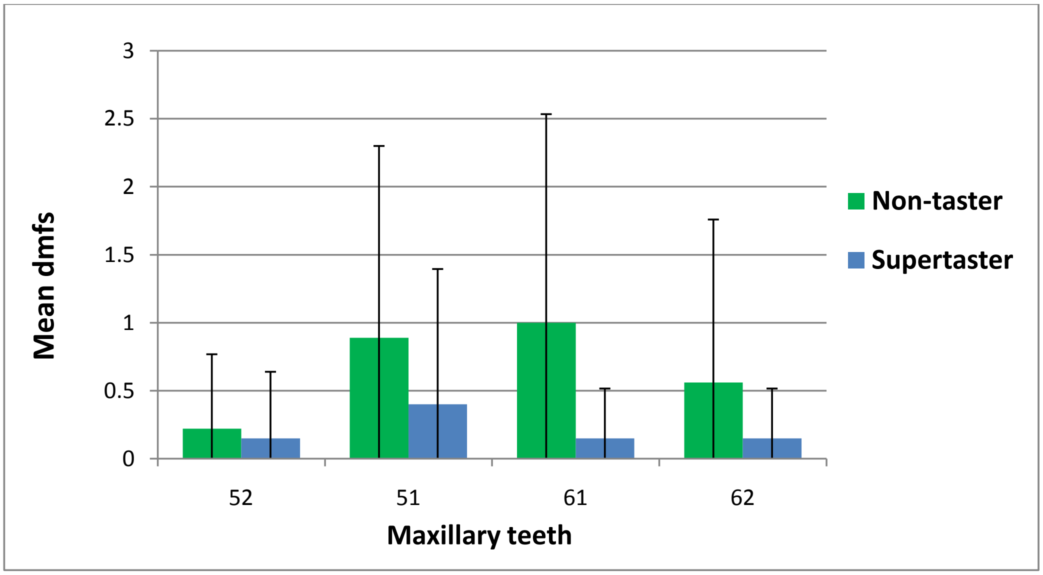


Figure 3. Mean (± SD) dmfs of maxillary anterior teeth in children of supertaster mothers and non-taster mothers (These individual differences were not tested.)

As a summary, all mean dmfs and white spot lesions in children from both groups of mothers in relation to demographic variables, oral hygiene factors and MS count, are shown in table 4a and b. In table 4a, one of the nineteen comparisons was significant and in table 4b, one of the eighteen comparisons was significant. In addition, a similar table summarized the mean dmfs and white spot lesions of maxillary anterior teeth only as related to other factors (Tables 5a and b). In table 5a, one of the nineteen comparisons was significant and in table 5b, none of the differences were significant.

Table 4a. Mean (standard deviation) dmfs and white spot lesions of all teeth in children of non-taster mothers and of supertaster mothers in relation to demographic factors

Variable	Children of non-taster mothers Mean (SD)		Children of supertaster mothers Mean (SD)	
	dmfs	WSL	dmfs	WSL
Child's age				
2yr	3.5 (4.2)	4.8 (4.6)	1.4 (3.7)	2.5 (3.9)
3yrs	4.3 (6.2)	2.8 (2.5)	2.0 (4.0)	1.3 (2.8)
Child's gender				
Male	3.2 (2.2)	5.2 (3.3)	1.6 (4.4)	3.1 (4.1)
Female	4.3 (6.6)	2.7 (3.6)	2.1 (3.9)	0.4 (0.8)
Mothers' age				
18-27	6.0 (7.3)	3.8(3.3)	2.5 (4.9)	1.9 (3.2)
28-37	2.1 (2.1)	3.1 (3.2)	1.2 (3.1)	1.6 (3.4)
38-45	3.5 (5.0)	4.5 (4.6)	n/a	n/a
Mothers' education				
High school or less	3.5 (3.7)	4.0 (3.8)	2.0 (4.7)	1.8 (3.3)
Some college or above	4.3 (6.7)	3.4 (3.6)	1.5 (3.2)	1.6 (3.2)
Mothers' ethnicity/race				
African American	3.27 (2.7)	3.1 (3.3)	2.6 (4.7)	0.7 (1.2)
White	8.0 (10.1)	6.2 (4.8)	0.0	1.5 (2.1)
Hispanic	1.0 (N/A)	3.0 (n/a)	0.0	5.5 (7.7)
Asian	1.0 (1.4)	2.0 (2.8)	0.0	0.0
Others	n/a	n/a	0.0	10.0 (n/a)
Mothers' dental caries				
Yes	4.4 (5.6)	4.2 (3.7)	3.1 (5.1)	1.8 (3.0)
No	1.3 (2.3)	1.0 (1.7)	0.2 (0.6)	1.6 (3.6)
Insurance coverage				
medicaid	4.3 (5.6)	3.6 (3.6)	2.6 (4.7)	1.5 (2.7)
private insurance	n/a	n/a	0.0	0.5 (1.0)
no insurance	2.0 (2.6)	4.0 (4.5)	0.0	5.5 (7.7)
Grandparents living in the household				
Yes	9.0 (6.6)†	5.8 (3.9)	1.3 (3.1)†	0.2 (0.7)
No	1.4 (1.6)	2.6 (3.1)	2.1 (4.7)	2.7 (3.8)

n/a : not available

† Significant, no other significant differences found

Table 4b. Mean (standard deviation) dmfs and white spot lesions of all teeth in children of non-taster mothers and of supertaster mothers in relation to oral hygiene factors and MS levels*

Variable	Children of non-taster mothers Mean (SD)		Children of supertaster mothers Mean (SD)	
	dmfs	WSL	dmfs	WSL
Frequency of toothbrushing				
never	12.5 (12.0)	4.0 (1.4)	0.0	3.0 (n/a)
once/day	2.0 (3.1)	3.1 (4.5)	3.5 (7.0)	1.5 (1.9)
twice or more/day	3.4 (3.5)	4.0 (3.6)	1.5 (3.3)	1.7 (3.6)
Frequency of sugary food				
rarely	1.6 (2.0)	6.6 (3.2)	0.3 (0.8)	1.8 (4.4)
once/day	1.6 (2.8)	3.0 (5.1)	0.0	1.8 (3.6)
twice/ day	2.7 (3.4)	2.7 (3.4)	4.7 (5.5)	1.7 (1.2)
three or more/day	12.0 (7.8)	4.3 (3.0)	5.3 (7.5)	1.3 (2.3)
Frequency of sugary drinks				
rarely	2.7 (3.5)	3.5 (2.8)	0.5 (1.0)	0.0
once/day	2.3 (2.0)	3.0 (4.3)	0.3 (0.8)	0.6 (1.2)
twice/ day	3.6 (6.3)	6.6 (5.8)	3.8 (5.2)	3.0 (4.5)
three or more/day	5.2 (6.7)	3.0 (3.0)	2.8 (6.2)	3.2 (4.1)
Baby bottle at bed-time with sweetened contents				
yes	5.6 (8.7)	3.6 (3.5)	2.3 (5.7)	3.3 (4.0)
no	3.3 (3.5)	3.7 (3.8)	1.6 (3.4)	1.0 (2.6)
Previous dental visits for caries or toothache	8.8 (7.6)	5.0 (3.6)	4.3 (4.0)	0.67 (1.1)
MS levels				
$<10^3$	3.0 (3.8)	2.5 (4.0)	0.7 (2.5)	1.3 (3.1)
$\sim10^4$	2.3 (1.5)	5.0 (2.6)	0.0	0.0
$>10^5$	6.8 (8.4)	5.4 (2.7)	4.0 (5.6)	2.7 (3.5)
Total MS levels (decayed surfaces only)	3.3 (5.1)†	3.7 (3.7)	1.4 (3.7)†	1.8 (3.2)

n/a : not available

† Significant, no other significant differences found

Table 5a. Mean (standard deviation) dmfs and white spot lesions of maxillary anterior teeth in children of non-taster mothers and of supertaster mothers in relation to demographic factors

Variable	Children of non-taster mothers Mean (SD)		Children of supertaster mothers Mean (SD)	
	dmfs of Mx Ant.	WSL of Mx Ant.	dmfs of Mx Ant.	WSL of Mx Ant.
Child's age				
2yr	3.1 (3.6)	1.6 (2.1)	0.8 (2.2)	0.0
3yrs	2.2 (3.4)	1.2 (2.1)	0.6 (1.4)	1.0 (2.3)
Child's gender				
Male	1.5 (1.8)	1.7 (2.4)	0.5 (1.5)	1.2 (2.7)
Female	3.2 (4.1)	1.1 (1.9)	0.9 (1.9)	0.1 (0.3)
Mothers' age				
18-27	3.1 (3.8)	0.8 (2.2)	0.6 (1.5)	1.3 (2.6)
28-37	2.0 (2.0)	1.5 (2.2)	0.8 (1.9)	0.0
38-45	2.7 (5.5)	2.0 (1.6)	n/a	n/a
Mothers' education				
High school or less	2.2 (3.5)	1.7 (2.5)	0.5 (1.5)	0.4 (1.2)
Some college or above	3.0 (3.6)	1.0 (1.5)	0.8 (2.0)	0.8 (2.6)
Mothers' ethnicity/race				
African American	1.9 (1.8)	1.5 (2.4)	1.0 (2.0)	0.3 (1.0)
White	5.5 (6.3)	0.5 (1.0)	0.0	0.0
Hispanic	0.0	2.0 (n/a)	0.0	0.0
Asian	2.0 (2.8)	2.0 (2.8)	0.0	0.0
Others	n/a	n/a	0.0	8.0 (n/a)
Mothers' dental caries				
yes	2.3 (3.7)	1.4 (2.2)	1.0 (2.2)	1.1 (2.5)
no	4.0 (0.0)	1.0 (1.7)	0.2 (0.6)	0.0
Insurance coverage				
medicaid	2.6 (3.7)	1.4 (2.2)	1.0 (2.0)	0.9 (2.3)
private insurance	n/a	n/a	0.0	0.0
no insurance	2.6 (2.3)	1.3 (1.1)	0.0	0.0
Grandparents living in the household				
yes	5.3 (4.6)†	1.6 (2.0)	0.1 (0.3)†	1.0 (2.4)
no	1.2 (1.7)	1.2 (2.0)	1.0 (2.1)	0.1 (0.3)

n/a : not available

† Significant, no other significant differences found

Table 5b. Mean (standard deviation) dmfs and white spot lesions of maxillary anterior teeth in children of non-taster mothers and of supertaster mothers in relation to oral hygiene factors and MS levels*

Variable	Children of non-taster mothers Mean (SD)		Children of supertaster mothers Mean (SD)	
	dmfs of Mx Ant.	WSL	dmfs of Mx Ant.	WSL
Frequency of toothbrushing				
never	7.5 (4.9)	1.5 (2.1)	0.0	0.0
once/day	2.0 (2.1)	0.3 (0.8)	1.2 (2.5)	1.0 (2.0)
twice or more/ day	2.0 (3.4)	2.0 (2.4)	0.6 (1.5)	0.6 (2.0)
Frequency of sugary food				
rarely	0.6 (1.1)	2.6 (3.0)	0.3 (0.8)	0.0
once/day	1.3 (2.3)	0.6 (1.1)	0.0	1.1 (3.0)
twice/ day	2.6 (3.6)	1.0 (1.5)	1.7 (2.8)	0.2 (0.5)
three or more/day	5.6 (4.7)	2.0 (3.4)	1.6 (2.8)	0.7 (1.3)
Frequency of sugary drinks				
rarely	0.5 (1.0)	3.0 (2.5)	0.5 (1.0)	0.0
once/day	2.0 (2.0)	2.0 (3.4)	0.0	0.0
twice/ day	3.6 (6.3)	0.6 (1.1)	1.4 (2.6)	0.2 (0.4)
three or more/day	3.5 (3.5)	0.6 (1.1)	1.0 (2.2)	2.4 (3.5)
Baby bottle at bed-time with sweetened contents				
yes	3.0 (4.7)	0.6 (1.3)	0.8 (2.0)	0.6 (1.6)
no	2.4 (3.0)	1.6 (2.2)	0.6 (1.6)	0.6 (2.1)
MS levels				
$<10^3$	3.1 (3.4)	0.7 (1.1)	0.1 (0.2)	0.1 (0.2)
$\sim10^4$	0.6 (1.1)	4.0 (2.0)	0.0	0.0
$>10^5$	2.8 (4.6)	1.2 (2.6)	1.8 (2.6)	1.7 (3.1)

*There were no significant differences in any of the comparisons

Oral health habits

Frequency of tooth brushing

The findings related to the tooth brushing habits of children are shown in Figure 4 and tables 4b and 6. More than two-thirds of the participant children were reported to have their teeth brushed at least twice a day while less than one-third of the children were reported to have their teeth brushed once a day. Of those children who brushed at least twice daily, the mean dmfs was lower (1.5±3.3) in the children of supertaster mothers than the dmfs (3.4±3.5) in the non-taster group but the difference was not statistically significant (F=2.698, p=0.083). A similar result was shown for the dmfs of maxillary anterior teeth, 2.0±3.4 for the non-taster group and 0.60±1.5 for the supertaster group (F=1.925, p=0.162). Only three children (7.9%) reportedly seldom had their teeth brushed. Two of them were in the non-taster group with the mean dmfs equal to 12.5±12.0, while one child in the supertaster group had no dmf surfaces (Table 4b).

Table 6. Two-way analysis of variance of dental caries in children versus PROP type and frequency of tooth brushing

Source	Mean dmfs	Standard deviation	F	p	Partial Eta Squared	Observed Power
PROP type						
Non-taster	3.94	5.3	4.185	0.049 †	0.116	0.51
Supertaster	1.85	4.0				
Frequency of tooth brushing						
Never	8.33	11.1	0.906	0.414	0.054	0.19
Once/day	2.60	4.7				
Twice or more/day	2.28	3.4				
PROP type * F tooth brushing			2.698	0.083	.144	0.49

† Significant

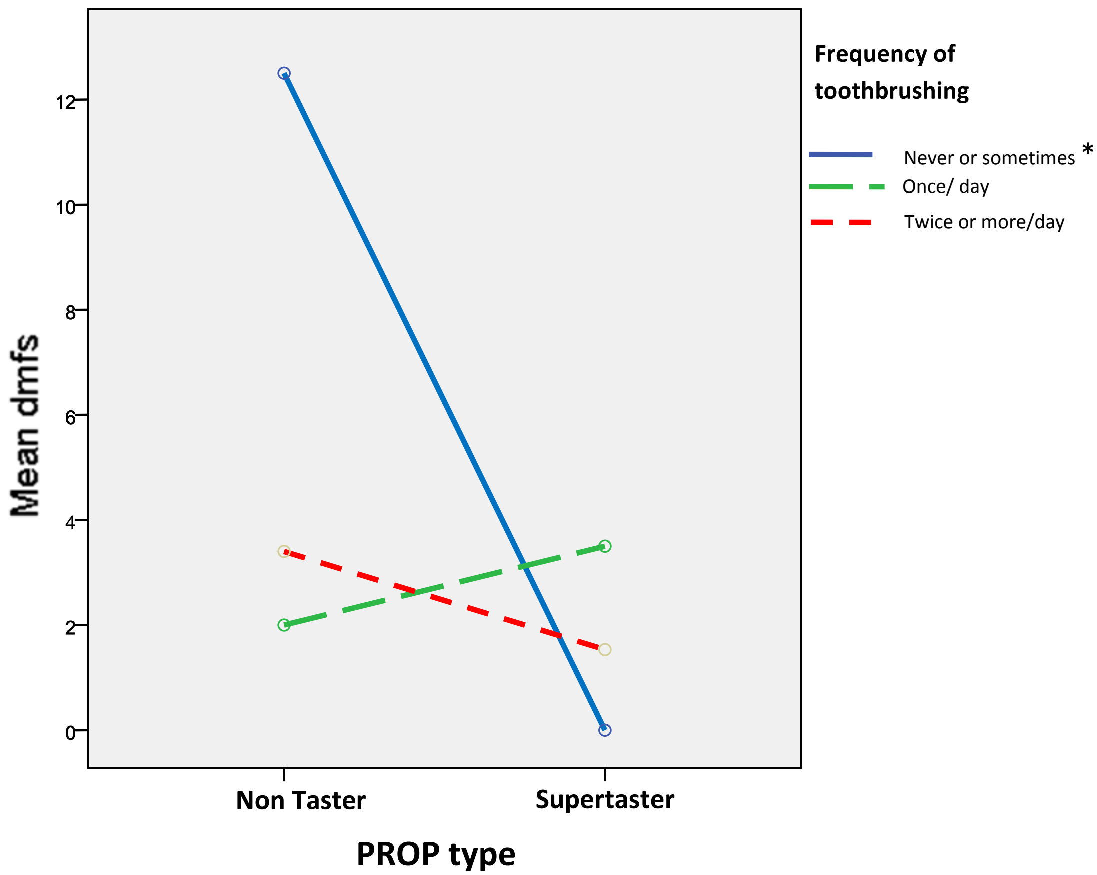


Figure 4. Mean dmfs relating to frequency of tooth brushing among children of non-taster and supertaster mothers (F=2.698, p=0.083)
* n=2 for non-taster, n=1 for supertaster

Frequency of sugar containing products

Nineteen children (50%) reportedly consumed sugary foods like sweets, candies, and cookies more than once a day. Twelve of nineteen (63%) were children of non-taster mothers whereas the majority of the children of supertaster mothers (65%) reportedly consumed sugary food once a day or less. The mean dmfs of all children who consumed sugary food three times or more a day was high (8.67±7.7) compared to the mean dmfs (0.78±1.3) of those who rarely consumed them (F=5.972, p=0.003). Three children in each group reportedly consumed sugary food three times or more times per day. Of those children, the mean dmfs was higher (12.0±7.8) in children of non-taster mothers than those of supertaster mothers (5.3±7.5) but no statistical difference was found (F=1.627, p=0.204). See Tables 4b, 7 and Figure 5. Similarly in those children with the highest sugar consumption, the mean dmfs of maxillary anterior teeth was high (5.6±4.7) in children of non-taster mothers as compared to that (1.6±2.8) in children of supertaster mothers (F=0.626, p=0.604, Table 5b).

Table 7. Two-way analysis of variance of dental caries in children versus PROP type and frequency of sugary food

Source	Mean dmfs	Standard deviation	F	p	Partial Eta Squared	Observed Power
PROP type						
Non-taster	3.94	5.3	1.971	0.171	0.140	0.27
Supertaster	1.85	4.0				
Frequency of sugary food						
rarely	0.78 a	1.3	5.972	0.003 †	0.374	0.92
once/day	0.50 a	1.5				
twice/day	3.38 a	4.0				
three or more/day	8.67 b	7.7				
PROP type * F sugary food			1.627	0.204	0.140	0.38

† Significant

Groups with the same letter are not significantly different

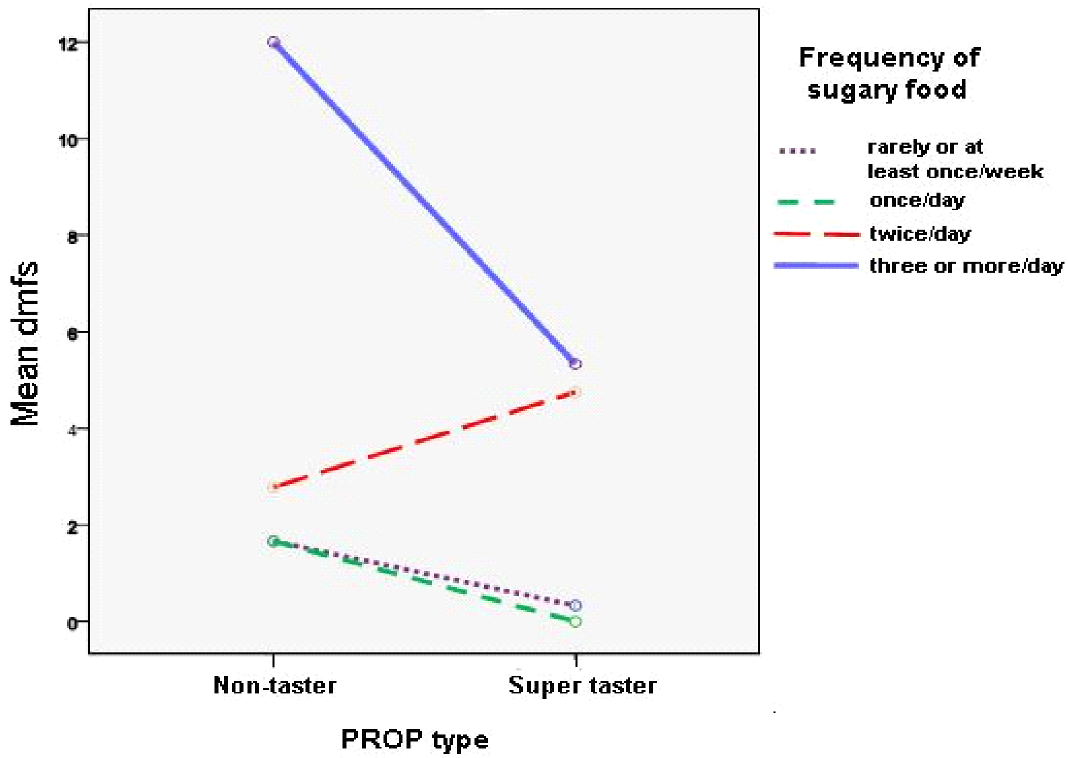


Figure 5. Mean dmfs related to the frequency of sugary food among children of non-taster and supertaster mothers (F=1.627, p=0.204)

More than once daily use of sugary drinks (e.g. juices) was at approximately 55% with equal distribution between children of non-taster and supertaster mothers. Children who consumed three or more sugary drinks a day had a higher mean dmfs (4.3 ± 6.4) than those who rarely consumed them (1.6 ± 2.7). No statistical difference was found (F=0.736, p=0.539, Table 8). In addition, the mean dmfs of children who frequently consumed sugary drinks in the non-taster group was higher (5.2 ± 6.7) than in the supertaster group (2.8 ± 6.2, F=0.121, p=0.947). There was no difference in the mean white spot lesions among non-taster and supertaster groups with respect to the reported highest consumers of sugary drinks. See Tables 4b and 8.

Table 8. Two-way analysis of variance of dental caries in children versus PROP type and frequency of sugary drinks

Source	Mean dmfs	Standard deviation	F	p	Partial Eta Squared	Observed Power
PROP type						
Non-taster	3.94	5.3	1.971	0.171	0.140	0.27
Supertaster	1.85	4.0				
Frequency of sugary drinks						
rarely	1.63	2.7	0.736	0.539	0.069	0.19
once/day	1.00	1.5				
twice/day	3.75	5.2				
three or more/day	4.31	6.4				
PROP type * F sugary drinks			0.121	0.947	0.364	0.07

Baby bottle

Slightly more than 81% of children had stopped the use of a bottle by one year of age or earlier. Only five mothers reported that their children still used a bottle. A little less than a third of the mothers reported that their children had sweetened drinks other than water, like juice, in their bottles at bedtime. Of those children, the mean dmfs of total teeth and the mean dmfs of maxillary anterior teeth were high (5.6 ± 8.7 and 3.0 ± 4.7, respectively) in the non-taster group but low (2.3 ± 5.7 and 0.8 ± 2.0, respectively) in the supertaster group (Tables 4b, 5b). There was no significant difference in the mean dmfs between the groups (F=0.219, p=0.643), (Table 9, Figure 6).

Table 9. Two-way analysis of variance of dental caries in children versus PROP type and drinking sweetened beverages at bedtime using baby bottle

Source	Mean dmfs	Standard deviation	F	p	Partially Eta squared	Observed power
PROP type						
Non-taster	3.94	5.3	2.073	0.159	0.057	0.29
Supertaster	1.85	4.0				
Bottle at bedtime						
yes	3.82	7.0	0.758	0.390	0.022	0.13
no	2.44	3.5				
PROP type * sweetened beverages at bedtime			0.219	0.643	0.006	0.07

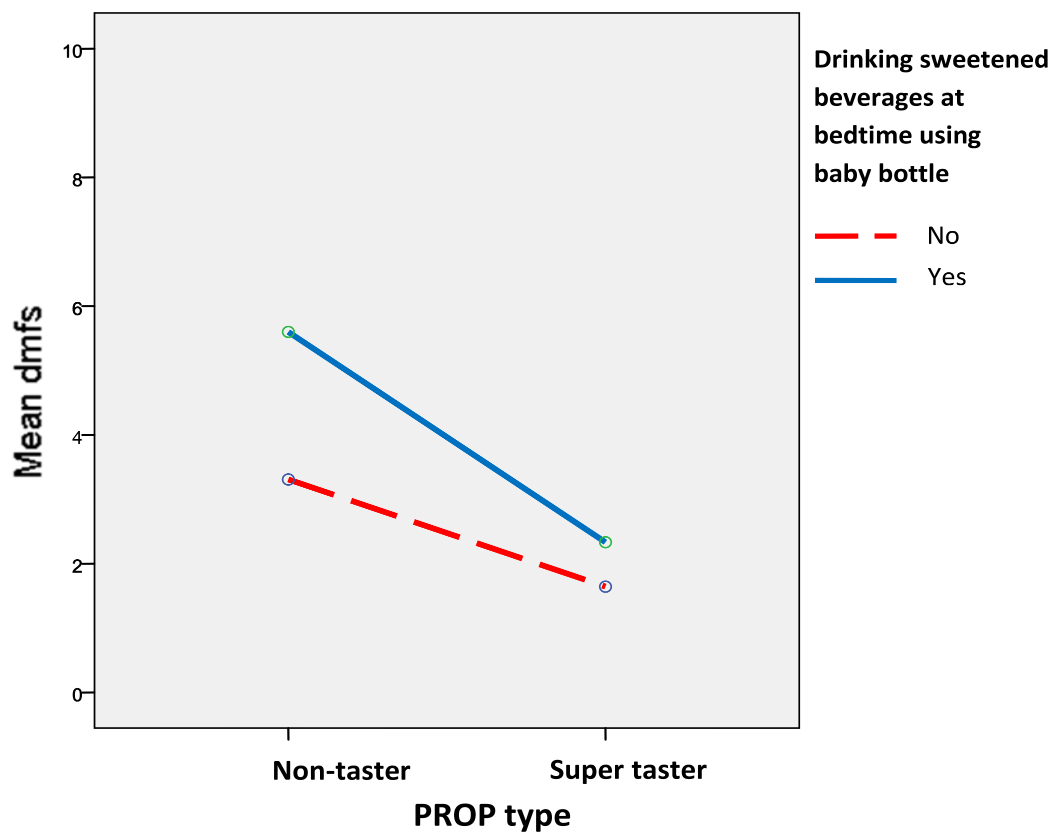


Figure 6. Mean dmfs in children related to mothers' PROP type and drinking sweetened beverages at bedtime using baby bottle (F=0.121, p=0.947)

Dental visits

Of all children, 13% had never visited a dentist, 84% had previous dental visits for cleaning and 21% had dental visits for caries or a toothache. Of those children who had visited a dentist for a cavity or toothache, children of supertaster mothers had a lower mean dmfs (4.3±4.0) than the mean dmfs (8.8±7.6) of those of non-taster mothers (F=1.203, p=0.280, Figure 7). Two-thirds of all children received previous applications of fluoride varnish.

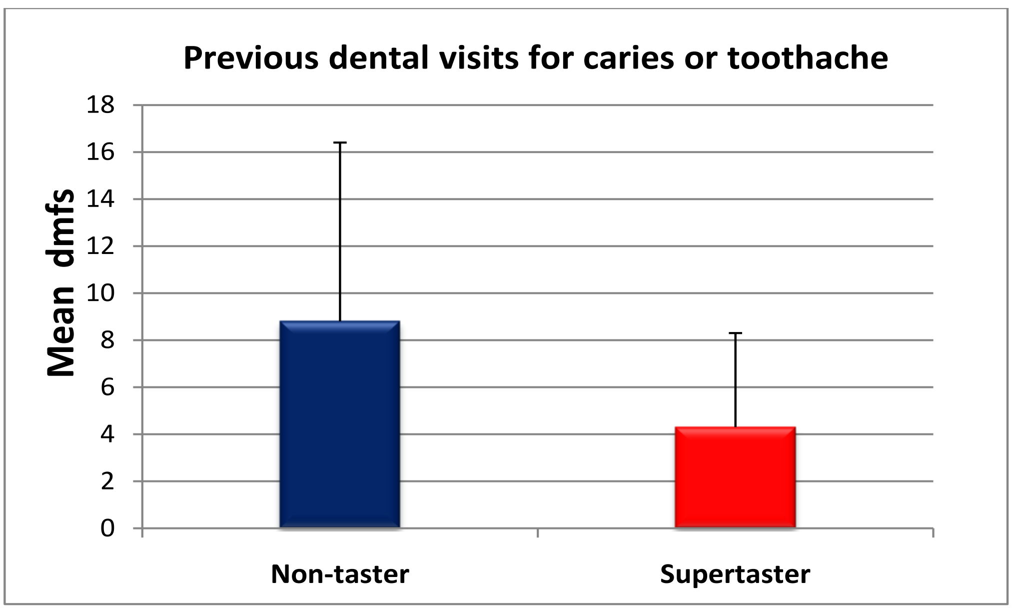


Figure 7. Mean (±SD) dmfs in children related to mothers' PROP type and previous dental visits for cavity or toothache (F=1.203, p=0.280)

Mutans Streptococci (MS) levels

In our sample, fifty-seven percent of the children were found to have low MS levels (<10^3CFU). Those children with low MS levels had a low mean dmfs (1.7±3.3). Only twelve children (31.5%) had high MS levels (>10^5 CFU) with their mean dmfs equal to 5.1±6.7 (Table 10). There was a significant difference in decayed surfaces (ds) between children of low MS (1.35±3.7) and high MS levels (3.28±5.1, F=4.105, p=0.025). Of those children with high MS levels, children from non-taster mothers had a higher dmfs (6.8±8.4) than those from supertaster mothers (4.0±5.6) with no significant difference (F=0.014, p=0.987). See Tables 4b and 10, Figure 8).

Table 10. Two-way analysis of variance of dental caries in children versus PROP type and MS levels

Source	Mean dmfs	Standard deviation	F	p	Partially Eta squared	Observed power
PROP type						
Non-taster	3.94	5.3	1.364	0.251	0.041	0.21
Supertaster	1.85	4.0				
MS levels						
<10^3	1.77	3.3	2.438	0.103	0.132	0.46
~10^4	1.75	1.7				
>10^5	5.17	6.7				
PROP type*MS levels			0.014	0.987	0.001	0.05

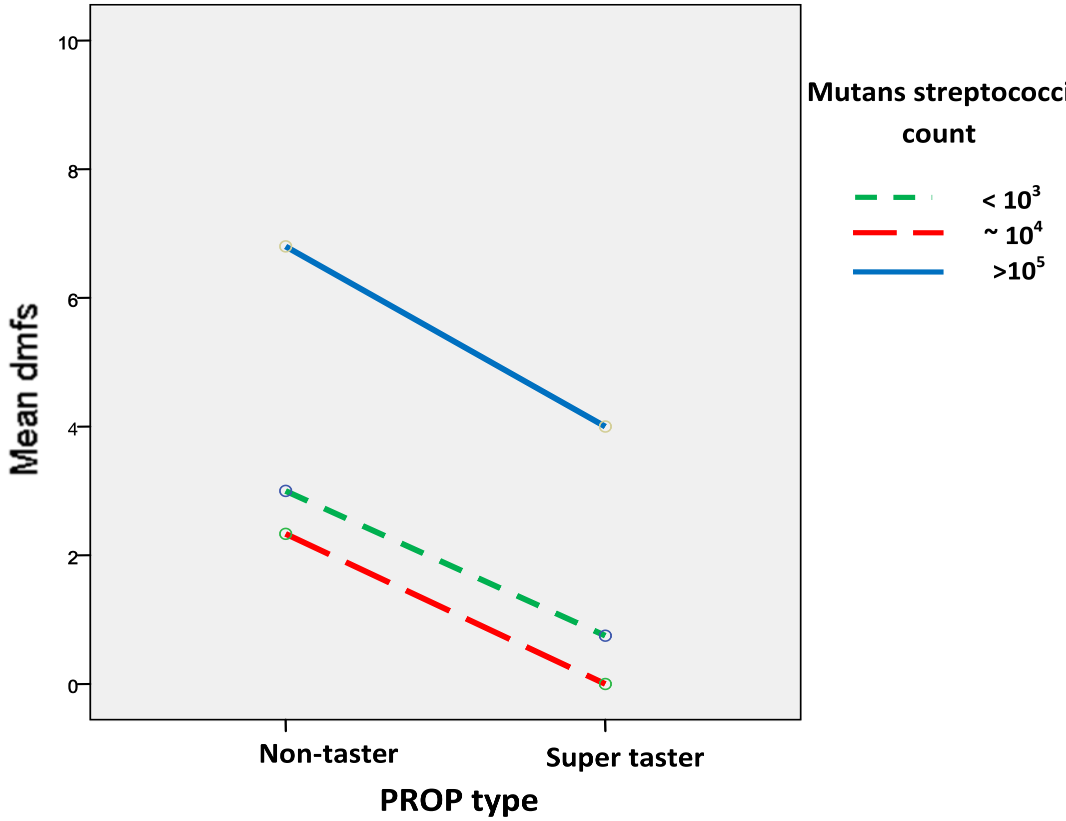


Figure 8. Mean dmfs in children related to mothers' PROP type and Mutans Streptococci (MS) count (F=0.014, p=0.987)

Mothers' demographic factors

Mother's age

Mothers were divided into three age groups as presented in Figure 9 and table 4b. Those mothers in the youngest age group had children with the highest mean dmfs (3.9±6.0) compared to the children in the middle age group (1.5±2.7) and those children in the oldest age group (3.5±5.0). The highest mean dmfs (6.0±7.3) was found in those children of mothers who were non-tasters in the youngest age group (Table 4a).

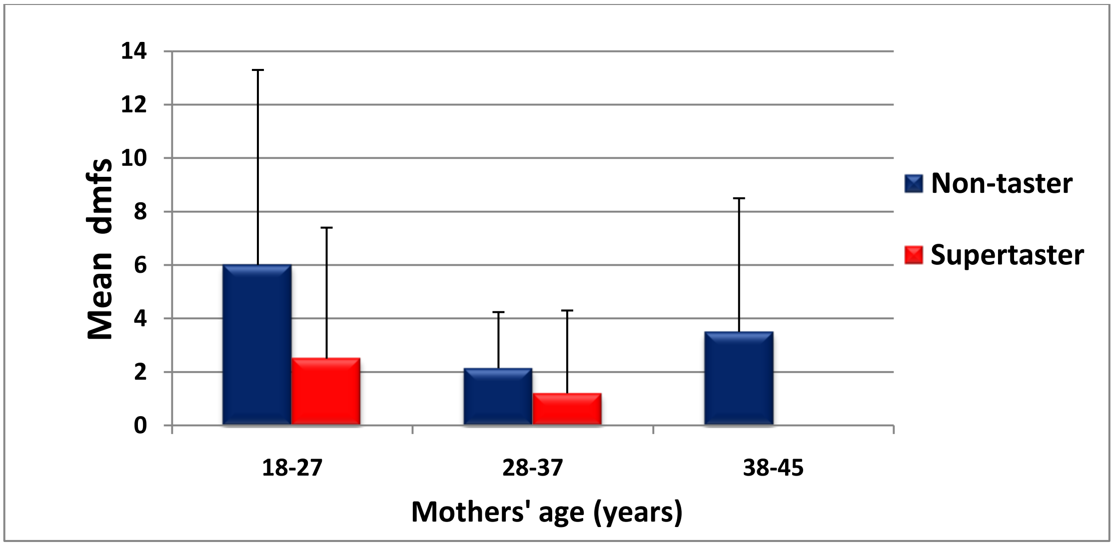


Figure 9. Mean (±SD) dmfs in children of non-taster mothers and supertaster mothers in relation to mothers' age groups

Mothers' race/ ethnicity

Most of the mothers (65.7%) in the sample were African-Americans. They were distributed equally between the two groups. No significant difference in mean dmfs was detected as a result of race/ethnicity. White mothers presented sixteen percent of the sample. Of those, White non-taster mothers had children with the highest mean dmfs (8.0±10.1) compared with children of White supertasters (0.0 dmfs). The rest were Hispanic, Asian, or of other races representing around eighteen percent of the sample. These mothers had children with low mean dmfs (1.00±1.4). See Table 4a.

Mothers' educational level

The mean dmfs of children of non-taster mothers was high in both levels of education: high school or less and some college or above (Table 4a). Non-taster mothers who had a high school education or less had children with a higher mean dmfs (3.5$\pm$3.7) than those of supertaster mothers (2.0$\pm$4.7). A similar finding was shown with the mean dmfs of maxillary anterior teeth and white spot lesions. No significant interaction was found between mothers' taste and education with respect to children's dmfs (F=0.175, p=0.679, Table 11, Figure 10).

Table 11. Two-way analysis of variance of dental caries in children versus PROP type and mothers' education

Source	Mean dmfs	Standard deviation	F	p	Partially Eta squared	Observed power
PROP type						
Non-taster	3.94	5.3	1.823	0.186	0.051	0.26
Supertaster	1.85	4.0				
Mothers' education						
High school or less	2.75	4.2	0.006	0.939	0.0	0.05
Some college or more	2.94	5.3				
PROP type *M education			0.175	0.679	0.005	0.07

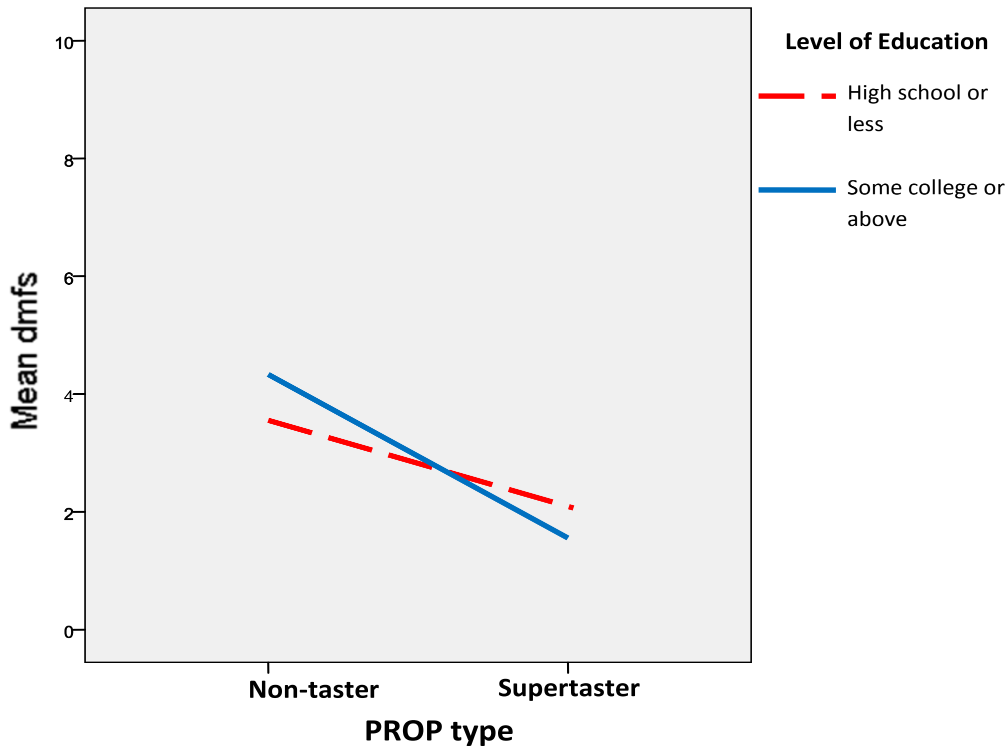


Figure 10. Mean dmfs of children related to mothers' PROP type and mother's Education (F=0.175, p=0.679)

Presence of maternal dental cavity

Mothers who reported that they had active dental caries made up sixty-eight percent of the sample. Their preschool children had significantly higher dmfs scores (3.9$\pm$5.3) when compared to the children of mothers reporting no dental caries (0.5$\pm$1.2, F=4.675, p=0.037). Figure 11 shows the distribution of the mean dmfs in children using the variables mothers' reported dental caries and mothers' taste type. No significant interaction was found between mothers' taste and mothers' reported dental caries with respect to children's dmfs (F=0.002, p=0.962, Table 12).

Table 12. Two-way analysis of variance of dental caries in children versus PROP type and mothers' reported dental caries

Source	Mean dmfs	Standard deviation	F	p	Partially Eta squared	Observed power
PROP type						
Non-taster	3.94	5.3	0.446	0.509	0.013	0.10
Supertaster	1.85	4.0				
Mothers' reported caries						
yes	3.92	5.3	4.675	0.037 †	0.078	0.38
no	0.50	1.2				
PROP type * M caries			0.002	0.962	0.000	0.05

† Significant

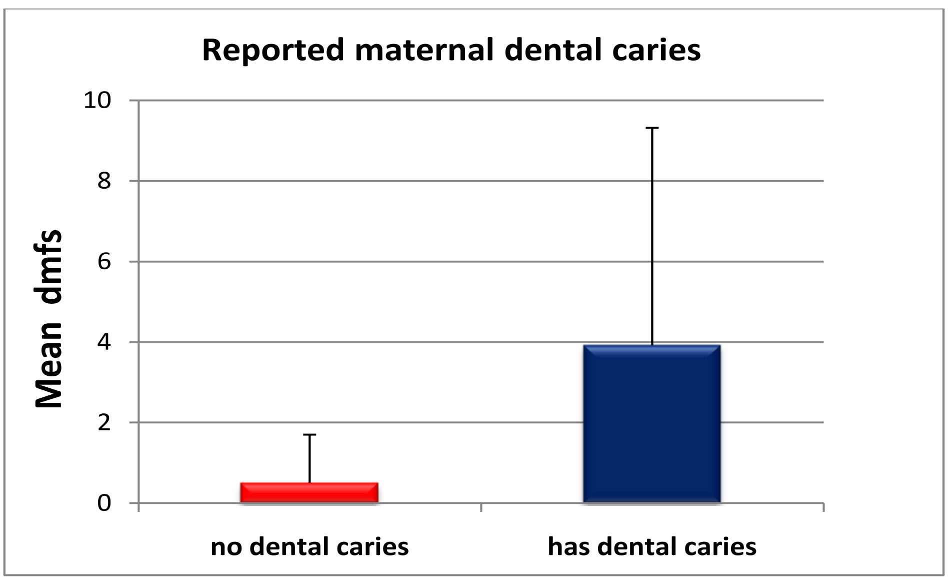


Figure 11. Mean (±SD) dmfs of children related to the reported maternal dental caries and mothers' taste type (F=4.675, p=0.037)

Presence of grandparents in the household

If grandparents lived in the same household as their grandchildren, the children had a significantly higher mean dmfs (4.6±6.1) compared to the dmfs (1.8±3.4) of those not living with their grandparents (F=6.084, p=0.019, table 13). As shown in table 4a, those families with grandparents living in the house and mothers being non-tasters had children with the highest mean dmfs score (9.0±6.6). There was a significant interaction between mothers' PROP type and grandparents living in the household on children's dmfs (F=9.251, p=0.005). Figure 12 illustrates this interaction.

Table 13. Two-way analysis of variance of dental caries in children versus PROP type and presence of grandparents in the household (GP)

Source	Mean dmfs	Standard deviation	F	p	Partially Eta squared	Observed power
PROP type						
Non-taster	3.94	5.3	6.234	0.018 †	0.155	0.68
Supertaster	1.85	4.0				
Grandparents living in same household			6.084	0.019 †	0.152	0.67
yes	4.64	6.1				
no	1.79	3.4				
PROP type* GP			9.251	0.005 †	0.214	0.84

† Significant

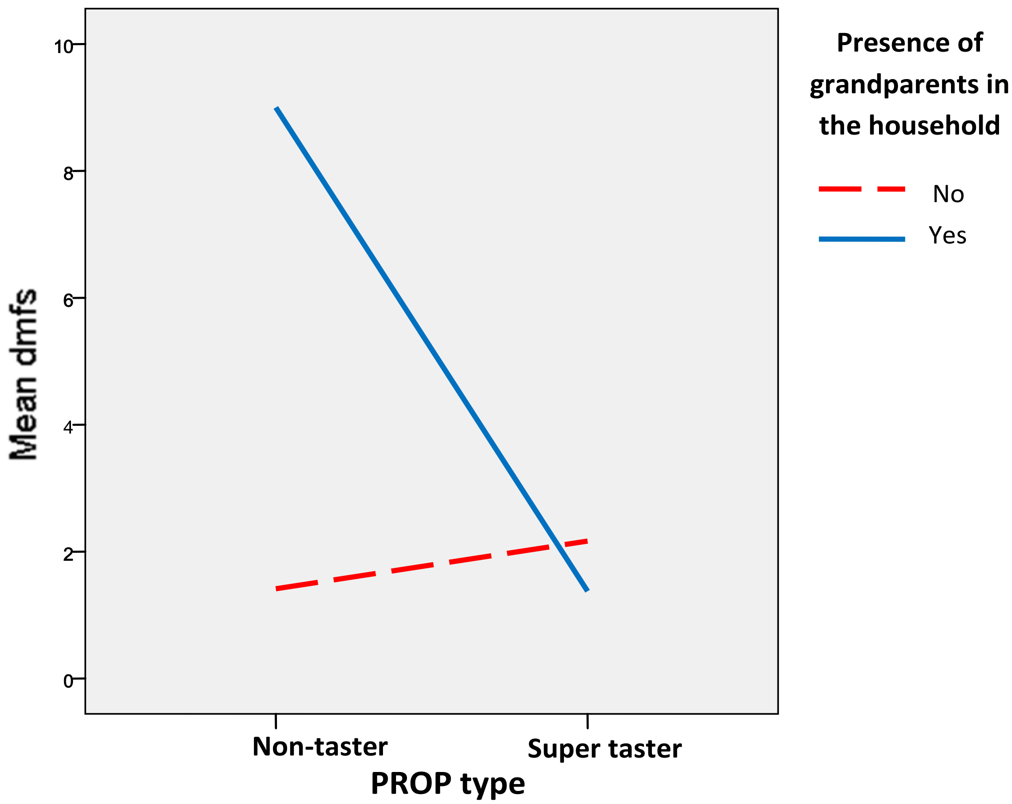


Figure 12. Mean dmfs of children related to mothers' PROP type and the presence of grandparents in the household (F=9.251, p=0.005)

Insurance coverage by Medicaid

The majority of the children (76%) were covered by Medicaid insurance. No significant interaction was found in the mean dmfs between the non-taster group and the supertaster group in relation to the type of insurance coverage (Tables 4a and 14, Figure 13). Four children were covered by private insurance and all of them had supertaster mothers and zero dmfs.

Table 14. Two-way analysis of variance of dental caries in children versus mothers' PROP type and type of insurance coverage

Source	Mean dmfs	Standard deviation	F	p	Partially Eta squared	Observed power
PROP type						
Non-taster	3.94	5.3	0.615	0.439	0.018	0.12
Supertaster	1.85	4.0				
Insurance coverage						
Medicaid	3.52	5.2	0.930	0.405	0.053	0.19
private	0.0	0.0				
no insurance	1.20	2.1				
PROP type* Insurance			0.004	0.948	0.000	0.05

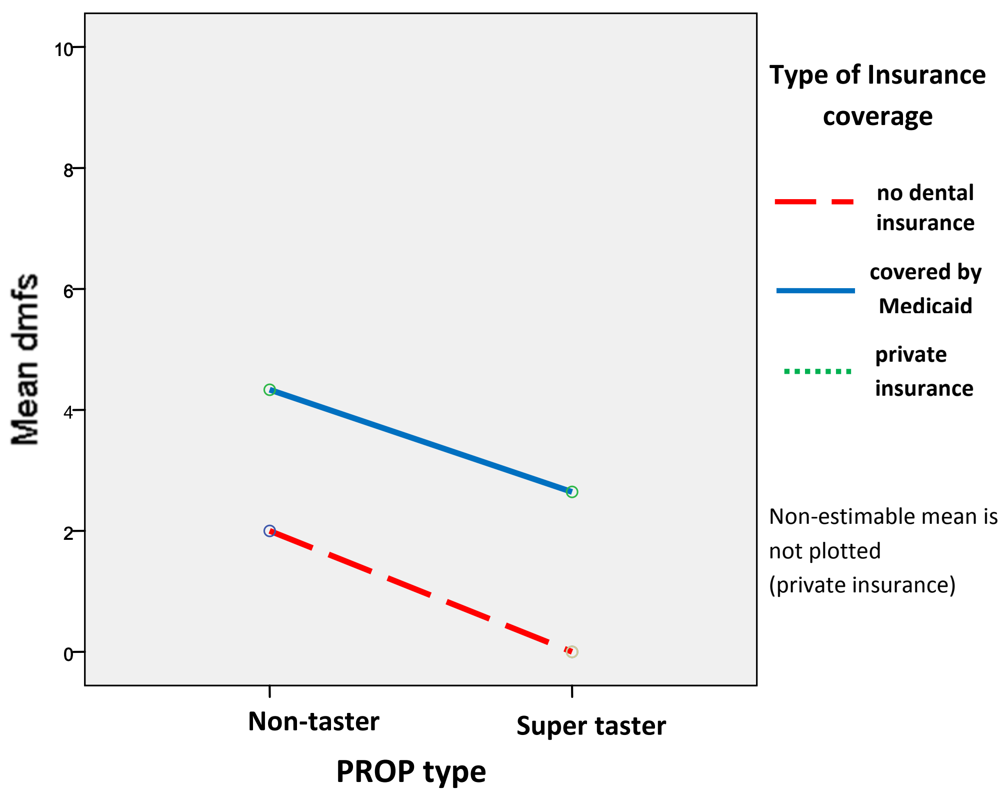


Figure 13. Mean dmfs of children related to mothers' PROP type and the type of insurance coverage (F=0.004, p=0.948)

Odds ratio for dental caries prevalence

Unadjusted odds ratios (95% Confidence Interval) were calculated for the dental caries prevalence in relation to the main factors: PROP type, mothers' reported dental caries, presence of grandparents, MS count, frequency of sugary food, and drinking sweetened beverages at bedtime (Table 15). Three factors have high odds ratios for the prevalence of dental caries: frequency of sugary food (8.13), mothers' reported dental caries (6.82), and PROP type (6.00). Two factors have low odds ratios for the prevalence of dental caries: high MS level (2.84) and presence of grandparents in the household (2.22). The odds ratio of drinking sweetened beverages at bedtime was almost zero (0.62) for dental caries.

Table 15. Unadjusted odds ratios (95% CIs) for dental caries prevalence in children

Variable	Unadjusted odds ratios for dental caries prevalence OR (CI)
PROP type (NT/ST)	6.00 (1.46, 24.5)
Grandparents in household	2.22 (0.58, 8.51)
Mothers' reported dental caries	6.82 (1.24, 37.5)
MS level	2.84 (0.71, 11.3)
Frequency of sugary food	8.13 (1.87, 35.2)
Drinking sweetened beverages at bedtime	0.62 (0.15, 2.60)

DISCUSSION

Studies have identified several risk factors for dental caries in preschool children. However, the influence of mothers' taste sensation, which leads to the preference for or rejection of sugary food products when feeding their preschool children, and subsequently on dental caries in their children, has not been documented. This study has tested the effect of mothers' taste perception on the dental caries experience of their young children. The genetics of taste may provide insight into individual differences in food preferences. The ability to taste bitter thiourea compounds, including 6-n-propylthiouracil (PROP) and phenylthiocarbamide (PTC) is inherited. [59] The PROP test proved to be a useful tool in determining the genetic sensitivity levels of the bitter taste.[57] Genetically mediated sensitivity to the bitter taste of PROP has long been associated with enhanced sensitivity to other oral sensations including sweetness.[61] These observations imply that this trait might serve as an index of general taste ability.[95]

In general, super tasters of PROP are more sensitive to bitter taste and sugar in foods, and often show lower acceptance of foods that are high in these taste qualities while non-tasters of PROP show the opposite characteristics.[74] Looy et al. reported that PROP non-tasters almost always like sweets, whereas supertasters almost always dislike sweets.[72] Hedge and Sharma also found that the majority of supertaster children did not prefer sweets and fatty food, but the majority of non-tasters preferred sweets and fatty food.[76] Similarly, Fenney et al. found that non-tasters had a significantly lower perceived sucrose intensity rating in both adults and children.[77] Thus, non-tasters may consume higher concentrations of sugars and have a higher frequency of sugar intake compared to supertasters.[77]

The role of taste sensitivity and the ability to taste sweet and its role in the risk of developing dental caries have been evaluated by several investigators.[56,74,75,78] If mother's PROP taste type affects dental caries in their children, such a test may facilitate the identification of very young children who are at high risk for developing dental caries.

Early childhood caries (ECC) is a relatively new term that encompasses all dental caries occurring in the primary dentition of young children from birth to 71 months of age.[5] ECC initially affects the primary maxillary anterior teeth of infants and young children. As the disease progresses, decay appears on the occlusal surfaces of the primary molars, with subsequent spread to all primary teeth, and if not treated may result in the eventual destruction of the primary dentition. The term severe early childhood caries (S-ECC) is used to refer to “progressive,” “acute,” or “rampant” patterns of decay. The diagnosis of ECC or S-ECC is dependent on the age of the child and extent of dental caries experience (decayed, missing, and filled tooth surfaces). ECC and S-ECC were diagnosed in this research according to the American Academy of Pediatric Dentistry definition.[5] The decayed, missing, and filled surfaces (dmfs) index and the presence of white spot lesions were used to determine the dental caries experience in these young children. Half of the participant children in this study were dental caries-free. S-ECC was found in thirty-three percent of the children, which is higher than that of other studies. Ismail et al. found in an inner city population that by 2 years of age, 27% of the subjects had S-ECC.[95] Another study based on national data found ECC prevalence to be 27.9% among 2- to 5-year-old children.[3] In contrast to dental caries prevalence in older children and adults, an increase in dental caries experience has been reported among young children aged 2 to 4 years, from 18 percent in 1988–1994 to 24 percent in 1999–2004.[2]

The results of the present study indicated that overall dental caries experience was higher for children of non-taster mothers than children of supertaster mothers. The prevalence of dental caries (dmfs $\geq$1, yes) in the children of non-taster mothers was significantly greater than dental caries in the children of supertaster mothers. A significantly greater dental caries prevalence was also found in children's maxillary anterior teeth of non-taster mothers as compared to children from supertaster mothers.

Maxillary anterior teeth of the primary dentition are early indicators of dental caries risk because they are the first to erupt and are immediately susceptible to carious attack if a child is fed with sugary foods or drinks and is infected with cariogenic bacteria.[96] Also, dental caries in young children frequently appears first on the maxillary primary incisors, where the liquids ingested by the infant sucking on a bottle or breast remain pooled away from salivary flow.[96] In contrast, the mandibular incisors are not dental caries susceptible because they are protected by the tongue and bathed in saliva. Thus, mandibular incisors show decay only with extremely severe caries challenge.[97,98] Children with caries of the maxillary anterior teeth may go onto develop dental caries in the posterior teeth if the initial risk factors are not changed. However, in our populations of 2-3 yrs. old children, dental caries rates in the posterior teeth may not have fully appeared because these teeth have not been erupted as long as the maxillary incisors.

Dietary patterns among children have shifted dramatically during the last few decades in the United States and worldwide.[99,100] Milk consumption has decreased while consumption of soft drinks and non-citrus juices and drinks has increased. Although the American Academy of Pediatrics recommends that fruit juice intake among 1- to 6-year-olds be limited to 4 to 6 ounces per day,[48] more than 10 percent of preschoolers in the

United States consume at least 12 fluid oz. of fruit juice per day.[101] Overall carbohydrate intake has increased from 46.3 percent of total energy intake in 1965 to 54.2 percent of total energy intake in 1996.[100] The frequency and amount of fermentable carbohydrates consumed influence the duration of exposure and retention of the food on the teeth.[102] Prolonged oral exposure of cariogenic foods may lead to extended periods of acid production and subsequent demineralization of teeth. Carbohydrates increase caries most if consumed between meals, and in a form that is retained for a long time in the mouth (e.g. toffee).[103]

What is unique about this study, it proposes that the taste preference in the mother may influence what the child is fed, and therefore may influence the dental caries risk of her children. Half of the mothers in this study reported the frequent daily consumption of sugary food in their children with the majority of them being children of non-taster mothers. As seen in table 7, the effect size, partial eta square, for the interaction was relatively high (0.14) and the observed power was 0.38. With a larger sample size, this interaction (Fig 5) might have been significant. Children with non-taster mothers, who consumed frequent sugary food, had dramatically high mean dmfs as compared to children of supertaster mothers. Perhaps a larger difference in effect size should have been used for the initial power analysis in this study. These results should be used in future power analyses. Also, preschool children who consumed sugary drinks three or more times daily were found to have a significantly higher mean dmfs than those who rarely consumed them. Of those children, the children of non-taster mothers who frequently consumed sugary drinks had a greater prevalence of dental caries than the children of supertaster mothers, but not significantly different because of the small number of subjects in the two groups.

It is known that children with dental caries eat sugary snacks between meals more frequently than those without dental caries,[104] perhaps resulting from their guardians' indulgence in giving the children sweets or snacks upon request. Mothers play an important role in feeding their babies and provide their early experiences with food and eating.[81] It was hypothesized that non-taster mother's dietary habits and tastes probably affected those of her child. Thus, non-taster mothers might tend to feed their young children with more sugary products resulting in an increased risk of dental caries.

Research has been shown that children choose to eat food that they have been given most often and prefer what is available and acceptable in the parental household.[105] Further, Beauchamp and Moran reported that 6-month old babies who were accustomed to drinking sweetened water preferred sweetened water at 2 years of age when compared to those babies who had little or no experience with sweetened water.[106] This suggests that even the apparently inherent preference for sweet tastes may be modified by familiarity.[91] Also, a greater maternal self-reported intake of fruits, vegetables, snacks/desserts and soda were associated with a greater variety of fruits, vegetables, snacks/desserts and soda, respectively, offered to their children at 13 months of age.[86,88] Contento et al found a relationship between mother's health motivation and the quality of their children's diet.[89] There was also a significant relationship between the mothers' ratings of the importance of health in food choices and their child's food intake in the Family Diet Study.[84] Indeed, current dental health education for the control of dental caries is based on earlier research and supports the promotion of dietary restriction of sugars to prevent dental caries.[107]

Certain feeding practices, such as bedtime bottle feeding, are associated to the development of dental caries.[108] Public health advocates widely believe that poor infant feeding practices, particularly feeding with juice in a bottle at bedtime, are associated with the development of dental caries in primary teeth. The association between dental caries and using a bottle for drinking liquids other than milk is also in line with other dental caries longitudinal studies.[1,47] Children who usually fell asleep while sipping milk or a sweet beverage at age 12 months were four times more likely to have dental caries than those who did not.[109] In this study, about a third of the children used a baby bottle that had sweetened contents other than plain water, such as fruit juices, at bedtime. Those children who slept with a bottle and had non-taster mothers experienced more dental caries compared to those that had harmful food behaviors and supertaster mothers. Thus, one could speculate that non-taster mothers who enjoy sweetened drinks would also feel that sweetened drinks would be a better pacifier for their children. This finding suggests that the frequent daily intake of sugary food along with mothers who are non-tasters are additive dental caries risk in children.

Douglass and colleagues have suggested that dietary factors other than bottle feeding may promote dental caries in primary teeth among young children.[99] However, four cohort studies of preschool children from the age of one to five years found that daily sugar intake and daily consumption of sugar-containing drinks, especially during the night, were significant risk factors in the development of ECC.[110-113] The continuous feeding of sugars at night-time, when flow rate of saliva is lowest, increases the dental caries risk significantly.[114] It was reported by Freeman and Stevens that mothers see the feeding bottle as an instant solution to household woes including an easier life for parents, relatively undisturbed sleep, and less stress and tension in the household. Therefore, mothers felt that, as the bottle ‘medicine’ appeared, the child’s disruptive behaviors disappeared.[115]

Tooth brushing is a well-accepted social norm. Children who establish this habit at an early age are likely to retain this behavior throughout life.[116] Ideally, tooth brushing should begin at home, with the eruption of the first tooth and under the supervision of parents. However, for some low-income families, the cost of toothbrushes and toothpaste has been identified as a potential barrier to regular tooth brushing.[117] Furthermore, twice daily tooth brushing is not the usual practice for many of these families. In areas without the benefit of fluoridated water, the provision of toothbrushes and fluoride toothpaste to all children at risk could have a significant effect in reducing dental caries. Although dental caries is caused by plaque bacteria on the tooth surface, there is a lack of clinical evidence showing that tooth brushing without fluoridated toothpaste is effective in dental caries prevention.[16] In the present study, children who reportedly performed tooth brushing more frequently experienced less caries than those who rarely brushed their teeth. This finding is in agreement with a number of studies in various child populations.[12] There are numerous studies showing that fluoridated toothpaste is effective in reducing dental caries in all age groups.[118,119] In the National Diet and Nutrition Survey (NHANES II), all children were using a fluoride toothpaste and the associations reported with tooth brushing may therefore be attributable to this source of fluoride rather than to mechanical cleansing.[119]

The findings in this study showed that children who brushed their teeth twice or more per day experienced more dental caries if their mothers were non-tasters compared to those of supertaster mothers. This could be explained by the deleterious effects of frequent sucrose consumption in the non-taster group irrespective of whether children maintained the recommended tooth brushing practice. Hinds and Gregory also found that frequent brushing of teeth did not outweigh the damaging effects of frequent sugar consumption.[119] In contrast, Gibson and Williams concluded that for children who brushed their teeth twice a day or more, consumption of sugars and sugary foods did not appear to be associated with dental caries.[120] Thitasomakul and colleagues found the highest incidence of dental caries in those children who did not bush daily by 9 months of age.[47] Also, Tsai and colleagues found that dental caries was strongly associated with a lack of proper brushing and a high consumption of sweets.[121] It was interesting to note that, in the present study, children who never brushed their teeth (n=2) and their mothers were non-tasters had the highest mean dental caries score (12.5 ± 12.0) as compared to the child whose mother was supertaster and never brushed his teeth (dmfs=0), but due to the small number of subjects, the result was not significant. The interaction in Figure 4 had relatively high effect size (0.144) and observed power (0.49). Therefore, this interaction should be studied further with a larger sample size.

Mutans streptococci (MS) is viewed as the principal bacterial species initiating dental caries in preschool children.[27,28] Elevated levels of MS ($>10^5$) in plaque and saliva have been associated with an increased dental caries experience.[28] Preschool children with elevated colonization levels of MS have greater dental caries prevalence as well as a much greater risk for new lesions than those children with low levels of MS.[37] In this study, decayed surfaces were significantly higher for the preschool children who had high MS levels. This finding was in agreement with many previous studies. A link between MS and dental caries has been found in studies involving a wide range of ethnic groups: Finnish[122], Australian aborigines[123], African-American and Hispanics[124,125], Swedish[126,127], Black and Colored in South Africa[128], Afro-Caribbean and White Caucasians in Britain[129], and Chinese.[130] If MS is present, whatever the ethnic group, it is a strong indicator of dental caries risk. In the present study, dental caries was higher in children with elevated MS levels in the non-taster group than in the supertaster group (6.8 ± 8.4 vs. 4.0 ± 5.6, respectively), but there was no significant difference, probably again because of the low number of subjects. Figure 8 confirms that children with high MS levels ($>10^5$) had high mean dmfs index. This confirmed the results from previous studies[37].

There has been great interest in the past several decades in determining how children become colonized with MS. Mothers have been found to be the primary source of the MS infection in their children,[33] with mother-to-child MS transmission occurring before a child is 2 years old.[33] Increased frequency of sugar consumption also has been associated with increased risk for MS colonization.[33] A four-fold increase in the odds of MS colonization has been found in children whose bottles contained sweetened beverages as compared with those whose bottles contained milk.[131] Rodents that consume sucrose-containing diets have greater MS colonization and dental caries than rodents consuming glucose-containing diets.[132,133] Similar findings have been reported in humans. Dental students given sucrose-rich diets for 2 weeks had MS as 2.1% of their streptococcal plaque flora, compared with 0.7% during a low-sucrose dietary period.[134]

Additionally, parents of 1-year-olds who were reported to consume sugar-containing beverages frequently, or to consume sugar-containing beverages at night, were more likely to be colonized with MS.[135] Thus, if a mother is a non-taster, it is possible that the increased frequency of sugar consumption could influence the colonization of MS bacteria in her child.

For mothers reporting active dental caries in our sample, their children had significantly higher dental caries experience than those of mothers reporting no active caries. However, mothers' status as a supertaster or a non-taster, did not significantly affect this relationship. Mothers' dental caries status has been related to preschool children's dental caries status in previous studies in Turkey[136], Thailand[47], New York[137], and in Maryland[138] but was not significant in a Japanese study.[139] Maternal risk indicators such as active decay, reported high sucrose consumption, and high MS level were identified as strong risk indicators for children's dental caries.[137] A recent study by Weintraub et al. found that maternal untreated dental caries almost doubled the odds of children's untreated dental caries and significantly increased the child's dental caries severity by about 3 surfaces.[140] It was also observed that neglected oral hygiene of mothers was associated with the manifestation of the dental disease among their infants.[141] Further, a positive correlation has been found between the carious activity of mother-child pairs.[116] These findings indicate that mothers' oral health status is a good risk indicator for their children.

Other maternal demographic variables like educational level and socio-economic status have been suggested by previous investigators as being associated with dental caries in children. Kinirons and McCabe reported a relationship between a mother's educational level and the caries experience of her children.[142] It was illustrated by Kinnby et al. that the parents' age and educational levels were important social background factors in pre-school children's dental health.[141] Also, Tinanoff suggested that sociodemographic factors may have an effect on dental caries risk, with children of higher social classes having lower dental caries levels.[143] Sociodemographic factors may be of even more importance for preschool children than for children later in life.[144] It was found that the major predictors of dental caries at age 3.5 years were microbial (mutans streptococci), social (mother's education and immigrant background) and dietary factors (sweets and soft drinks). These were all cumulative and when all these sociodemographic risk factors were present the probability of manifest dental caries was 79.8%.[127]

It was documented that children from low-income households who are enrolled in the Medicaid program are at a higher risk of developing dental caries and may require a more intensive mix of services to meet their dental needs as compared with their more economically advantaged counterparts.[145] This also was confirmed by a Brickhouse study that found children enrolled in public insurance programs had more untreated dental caries than did children who were not enrolled[146], perhaps due to the limited number of dentists who are willing to provide dental services for children on Medicaid.[147,148] Also, Sohn et al. found that children's dental insurance was a significant determinant of child dental visits among a low-income underserved population.[149]

In addition, mother's socioeconomic status is a widely accepted factor affecting unhealthy food behaviors.[150] These associations between mother's education level or socio economic status and the dental caries experience of her child were not found, in the present study, to be significant indicators of childhood dental caries risk. Although children of non-taster mothers from low income families with a low level of education showed a slightly higher dental caries level than children of supertaster mothers with the same characteristics, no significant difference was found in this study. Lack of the effect of socio-economic variables in the present study is perhaps due to the poor distribution of these variables in the population that was studied.

In this investigation, the dental caries experience of preschool children of non-taster mothers living together with either or both their grandparents in the same household was found to be significantly higher as compared to those of super-taster mothers. The mean dmfs of children whose mothers were supertasters and were living with their grandparents was approximately equal to the mean dmfs of children of non-taster mothers and supertaster mothers when no grandparent was living in the same household (Fig 12). It was reasoned that grandparents bring up children indulgently and give them more sweets regularly, thus causing their grandchild to be at a higher risk for dental caries. There is some evidence for rewarding as a critical feeding strategy for the child's unhealthy food intake.[151] Ohsuka et al. reported that the odds of the presence of dental caries in infants living with a grandmother or a grandfather were nearly four-fold higher than those for infants living with neither a grandmother nor a grandfather. He also found that dental caries prevalence was higher or tended to be higher when the daytime caring person was a grandmother than when the daytime caring person was the mother or the nursery school staff .[152]

In the present study, a comparison between dental caries-free children and those with dental caries (dmfs $\geq$1) showed that the prevalence of dental caries was found to be 6 times (unadjusted OR=6.00) more likely to be higher in the children of non-taster mothers than those of supertaster mothers. Although the present study did not have enough subjects to allow for an adjusted odds ratio analysis, it suggests that PROP type is a strong risk factor for dental caries in young children, close to that of mothers' reported dental caries which in our study had an unadjusted odds ratio of 6.82, and the frequency of consuming sugary foods which had an unadjusted odds ratio of 8.13.

The unadjusted odds for frequency of sugary food consumption, in the current study, was found to be consistent with that of Holbrook et al.[153],who reported that frequent sugar consumption was the most significant factor when predicting dental caries in the preschool children (OR = 6.46).[153] Burt and Pai, in a meta-analysis review, found that sugar consumption is a mild-to-moderate risk factor for dental caries in the modern age of fluoride exposure as compared to earlier years.[154] But, they concluded that sugar consumption is likely to be a more powerful indicator for risk of dental caries in children who do not have regular exposure to fluoride. A recent study by Parisotto et al. also found that high sugar consumptions (OR= 5.45) and high levels of mutans streptococci (OR=2.28) was significantly associated with dental carious lesions in preschool children.[155] They concluded that dietary sugar experience influenced the microbiological composition of dental plaque. Moreover, the early stage of dental caries was highly affected by mutans streptococci and visible dental plaque on maxillary incisors whereas caries were strongly related to lactobacilli and total microorganism levels.[155] A similar odds ratio (unadjusted OR =2.84) for high levels of mutans streptococci was found in the study.

In addition, odds ratio analysis in the current study shows that mothers' reported dental caries increases the risk of dental caries in their children approximately 7 times (unadjusted OR, 6.82) more than that in the children of mothers who reported no dental caries. This result is higher than that reported by Dye et al. who found that mothers who had high levels of untreated caries were more than three times as likely to have children who had an increasing extent of dental caries experience as compared with children whose mothers had no untreated caries.[156] Also, this study showed that the prevalence of dental caries was two times more likely (unadjusted OR=2.22) to be higher in the children whose grandparents live in the same household as compared to those children whose grandparents do not live in the same household. A Japanese study by Ohsuka et al. identified that the dental caries incidence in children aged 3 years, in the urban area, tended to be high (odds ratio=3.86) when they lived with their grandparents as compared to those living with neither a grandmother nor a grandfather.[152] The influence of grandparents on the dental caries prevalence in their grandchildren might differ in areas with clearly different lifestyles and, thus, it is important to analyze these areas separately. Moreover, the influence of non-taster mothers together with grandparents on children's oral health that have been found, in the present study, might be explored further in future research.

Despite the fact that the present study demonstrated a significant relationship between a mothers' taste perception and the prevalence of dental caries and the mean dmfs in the maxillary anterior teeth of their preschool children, there are some study shortcomings. The child status of living with someone other than his or her mother is a confounding variable that may give more variance to the relationship of mothers' genetic taste perceptions and dental caries in their children. Additionally, the sample size was too small to identify a significant effect of mothers' taste perception on the total dental caries experience of their preschool children. It also is a well-known fact that dental caries is affected by multiple factors that might hide the effect of the taste variable and children living with grandparents. In addition, in the present study not all possible dental caries risk and protective factors were assessed and controlled for in this study (e.g. fluoridated drinking water, saliva flow rate). Furthermore, inaccurate replies to the child's sugar consumption questionnaire are unavoidable and would be expected to produce false negatives rather than false positives. In addition, children included in this investigation were generally from low socioeconomic backgrounds and primarily of African-American descent. Therefore, the findings may not be generalizable to all children. Future studies with a larger sample size and a diverse ethnicity/race background are recommended.

Conclusion

The current study is the first to examine the relationship between mothers' genetic taste preference and the dental caries experience of their preschool children. Overall, the findings suggest that mothers who genetically prefer sweet foods have preschool children with higher dental caries experience at an earlier age as compared to mothers who dislike sweets. This finding may be an important variable that may help explain the dental caries experience of very young children. Dental health professionals might consider this when they assess dental caries risk in this population. Also, the study found increased dental caries experience in children whose mothers have untreated dental caries and in children living with their grandparents. Hence, more attention should be paid to those risk factors in young children. New knowledge about the influence of mothers' taste on the dental caries experience of their preschool children will pave the way for other research in the field and allow this phenomenon to be studied more fully.

APPENDICES

Appendix A — Demographic form

DEMOGRAPHIC AND CONTACT INFORMATION

A. Personal Information

Name: Mrs. Ms. Miss Dr.

____

Last First Middle

Address: ____

No. Street Apt. No.

____

City State Zip Code

Telephone: Home:(____) _______-___________ Work: (____) _______-__________

Cell: (______) _______-____________Email__________________________

Date of birth: _______/_____/_______ Age: ________

month day year

Height:____________ Weight: ___________

Occupation:____________________

* Ethnicity:

1. White
2. African American
3. Hispanic or Latino
4. American Indian
5. Asian
6. Mixed Race or Ethnicity

*Education level:

1. Elementary
2. Less than high school
3. High school graduate or GED
4. Some college
5. College graduate

*Total number of family members (18 or under) living in the household? ________

*Does your child's grandmother and/or grandfather live with you in the household? __________

* Have you ever had any problem with cavities or tooth abscess?___________

*Are you covered by Medicaid? 1. Yes 2. No

Appendix B — Oral hygiene questionnaire

Questionnaire

Please answer the following questions (**for child**):

Name of the child : ____

Date of birth : ____/_____/______ Sex (M / F): ________

Does your child have any medical problem? ______ if yes, what?________________

Does your child take any medications? ________ if yes,what?________________

How many times your child brushes his/her teeth per day?	1. Never 2. Sometimes, but not everyday 3. Once a day 4. Twice a day 5. More than twice a day
Do you or another adult help your child brush his/her teeth ?	1. No, my child brushes alone 2. Yes, sometimes 3. Yes, most of time 4. Yes, always
Does your child toothpaste contain fluoride?	1.Yes 2. No 3. Don't know
Does your child drink from a bottle?	1. Yes 2. No
At what age did your child stop drinking from a bottle?	1. Never drank from a bottle 2. Younger than one year 3. One year old 4. Two years or older
Does your child drink anything other than water from a bottle or sippy cup at bedtime?	1. Yes 2. No 3. Don't know
How often does your child eat sweets or sugary food (for example, candy, cookies, ice cream..) ?	1. Rarely or never 2. At least once a week 3. Once a day 4. Twice a day 5. Three times a day 6. Four times a day 7. Five or more times a day
How often does your child drink sweet or sugary drinks (for example, juice, soda, Coke, Pepsi...) ?	1. Rarely or never 2. At least once a week 3. Once a day 4. Twice a day 5. Three times a day 6. Four times a day 7. Five or more times a day

Has your child ever been to the dentist? If yes, how many times?	1. Yes 2. No 3. Don't know -------------- times
Has your child been to the dentist for a routine check up or cleaning?	1. Yes 2. No 3. Don't know
Has your child been to the dentist for a cavity or toothache?	1. Yes 2. No 3. Don't know
During the past year, has your child had fluoride varnish put on his/her teeth ?	1. Yes 2. No 3. Don't know

Thank you for your cooperation ☺

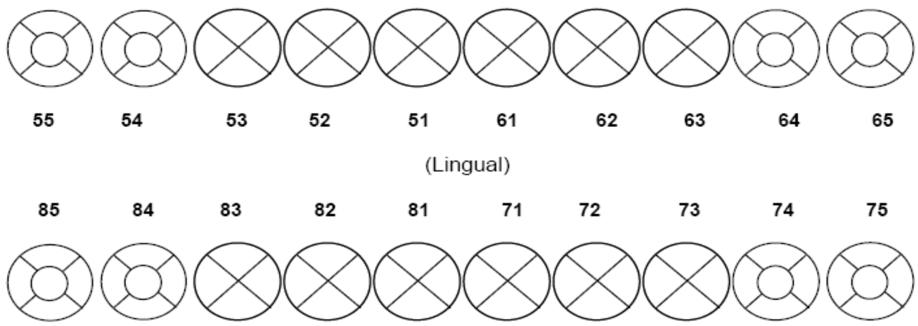
Appendix C — Clinical examination form

Clinical Examination Form

Date of examination: ___/___/____

Name:______________________________________

Date of Birth: ____/____/_____ Age: ______ Sex: _____



55		61		75		81	
54		62		74		82	
53		62		73		83	
52		64		72		84	
51		65		71		85	

<u>Coding system: (First pass)</u>

p = present
u = unerupted
r = partially erupted
s = sound
c = crown

m = missing due to caries
t = missing due to trauma
x = missing due to exfoliation
o = missing due to other

<u>Coding system: (Second pass) for p and r teeth</u>

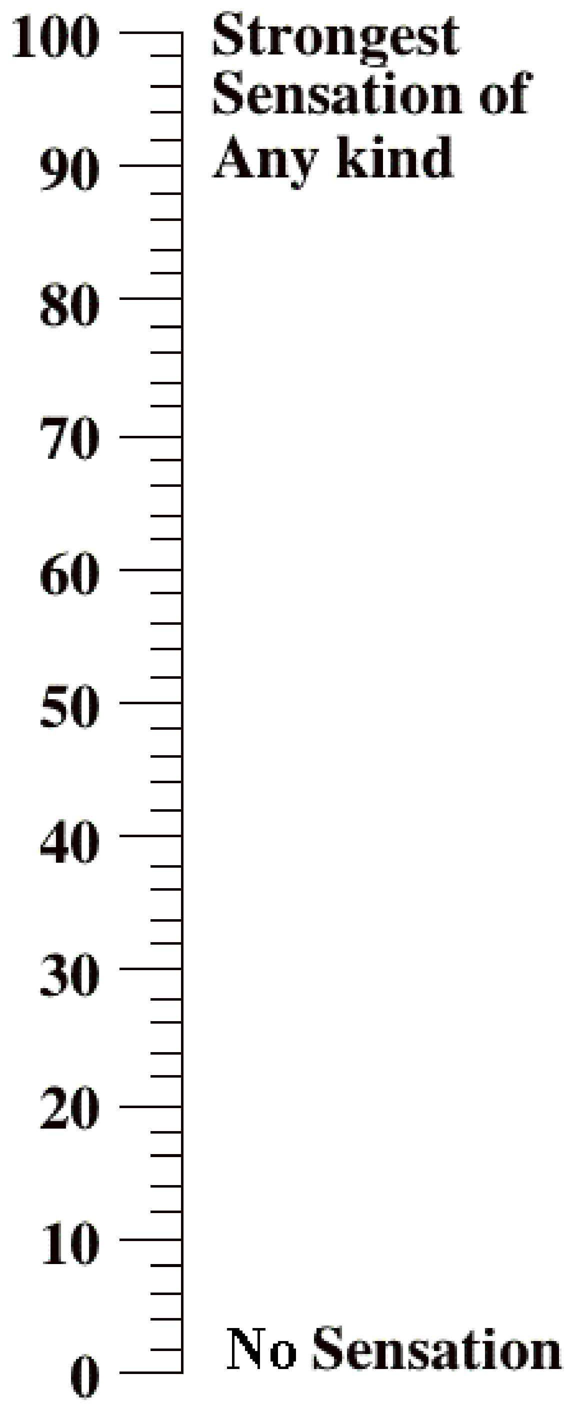
k = sound
d = cavitated (decayed)
w = deminerlized(white spot)
f = filled
s = sealed

<u>Surface codes</u>:

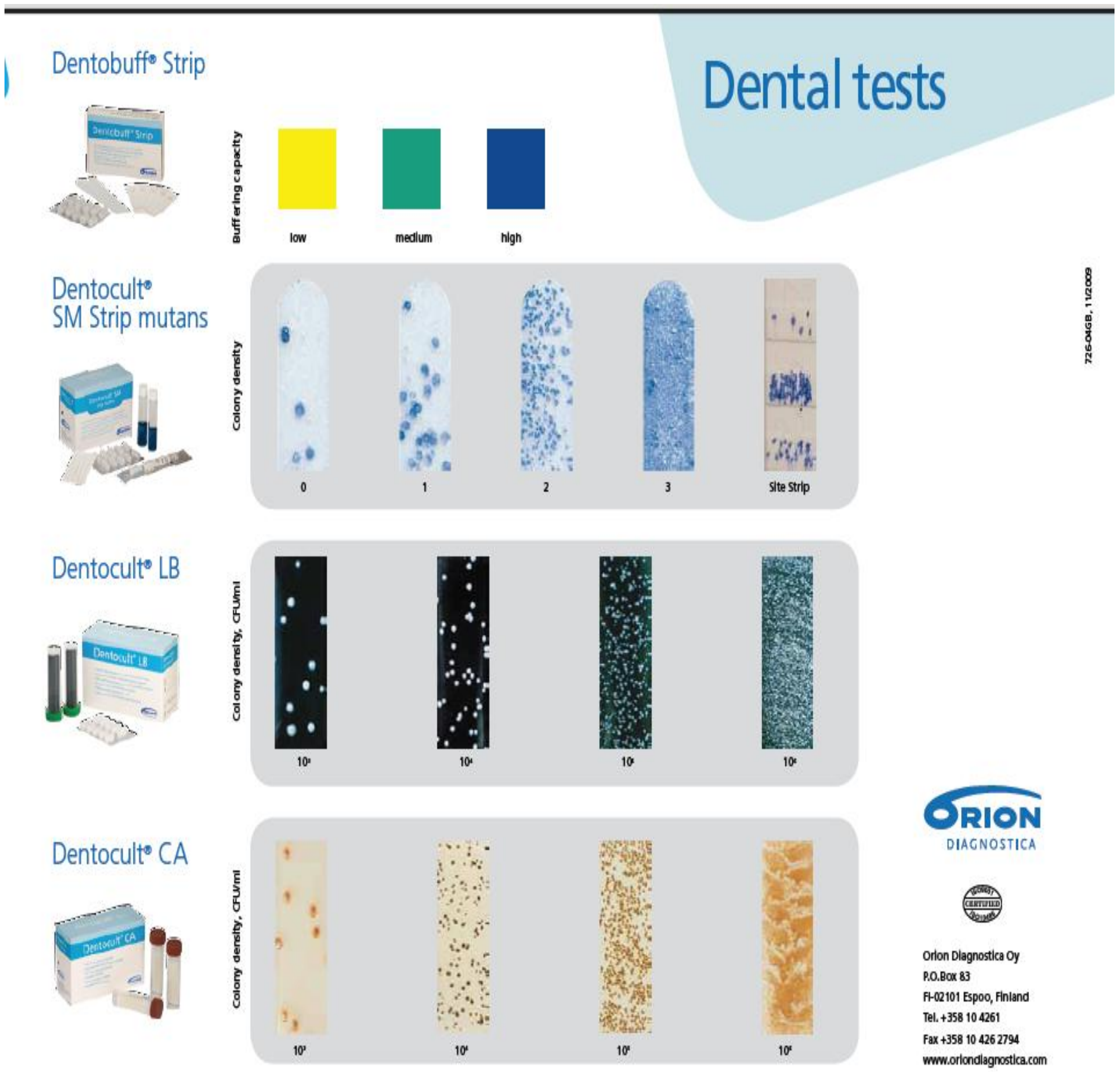
1 = buccal / facial
2 = occlusal
3 = lingual
4 = distal
5 = mesial

Appendix D — Taste scaling chart

Name:____ **Date**_________



Appendix E— Colony density chart (by manufacturer)



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