ORIGINAL RESEARCH

# Association between Severe Early Childhood Caries, Dietary Preferences, and 2nd Digit–4th Digit (2D:4D) Ratio

Sandeep K Srivastava[1], Nishita Garg[2], Lumbini Pathivada[3], Ramakrishna Yeluri[4]

## Abstract

**Background and aim:** To evaluate the association between severe early childhood caries (S-ECC), dietary preferences, and 2nd digit–4th digit (2D:4D) ratio. The objective is to contrast the detection and prevalence of dental caries in children with different sensitivity levels to the bitter taste of 6-*n*-propylthiouracil (PROP) and its association with 2D:4D.

**Materials and methods:** A total of 300 children below 71 months of age were assigned to two study groups—group I (caries-free) and group II (caries). PROP sensitivity test was carried out to determine the inherent genetic ability to taste a bitter or sweet substance. Evaluation of dietary preferences was carried out using a food preference questionnaire, which was completed by the parents of the children to know the child's dietary habits and their sweet, sour, and strong taste preferences. The length of the index (2D) and ring (4D) finger was measured with the help of digital vernier caliper to record the 2D:4D ratio. The data obtained was subjected to statistical analysis using Pearson's Chi-squared test and one-way analysis of variance (ANOVA).

**Results:** The results suggested a positive association between S-ECC and dietary preferences but could not establish a straightforward **1:**1 relation between 2D:4D ratio and S-ECC.

**Conclusion:** An individual considered as nontaster by PROP test was a sweet liker with low 2D:4D ratio having high caries index. The association between 2D:4D ratio and S-ECC should further be explored by taking other influencing factors into consideration before arriving at a definitive conclusion.

**Keywords:** 6-n-propylthiouracil, Caries experience, Food preference, Taste perception.

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## Introduction

Early childhood caries (ECC) is a very common oral disease that affects infants and children. The prevalence of ECC is about 6–90%, with the developed countries showing lesser prevalence compared to the developing countries.[1] Various studies have established a strong correlation between excessive consumption of sweet foods and unbalanced diet with ECC.[2] High amounts and more frequent sugar consumption by children increase their risk of developing caries.[3] Children suffering from severe ECC (S-ECC) tended to consume more liquid and solid cariogenic food when compared to caries-free children.[4] According to Desor et al.,[5] and Maciel et al.,[6] various biological, psychological, communal, cultural, and indirect factors affect the quantity of sugar intake.

Taste sensitivity is one factor that plays a key role in food choices affecting the intake, which impacts general and oral health and disease. The genetic sensitivity to taste is an inherited characteristic in children that may influence their preference or refusal of various foods.[7] Children may be tasters or nontasters as determined by their taste threshold to the naturally occurring pungent compound, 6-*n*-propylthiouracil (PROP).[8] Tasters include individuals with high sensitivity at low concentrations (low threshold) to PROP, while nontasters have poor sensitivity at low concentrations (high threshold).[9]

Previous studies have hinted at a connection between status of PROP and sweet preference.[9] Some researchers have speculated that nontaster children may have higher and more frequent sugar intake in comparison to taster children.[2,10] Since it is well-known that food intake plays a vital role in causing dental caries, for example, intake of sugared beverages/soda, starch, and sugar uptake, it implies that if nontasters prefer and ingest more amount of sweets than tasters who have lesser affinity toward sweets, status of PROP may be helpful in identifying children with a higher risk of caries.

Recently, the ratio between 2nd and 4th digit lengths has been established as a new risk marker for metabolic syndrome,[11] chronic heart disease,[11] dental caries,[12,13] and malocclusion.[14] The second and fourth fingers are influenced by in utero exposure to androgens (e.g., testosterone).[15] Ratio between index finger and ring finger can be utilized to determine prenatal exposure of androgen. The concept of ratio of digital finger was first given by Baker.[16]

[1]Department of Pedodontics & Preventive Dentistry, Dental College, Azamgarh, Uttar Pradesh, India

[2]Department of Pedodontics & Preventive Dentistry, Dental Institute, Rajendra Institute of Medical Sciences (RIMS), Ranchi, Jharkhand, India

[3]Department of Pedodontics & Preventive Dentistry, Rungta College of Dental Sciences & Research, Bhilai, Chhattisgarh, India

[4]Department of Paedodontics & Preventive Dentistry, Teerthanker Mahaveer Dental College & Research Centre, Moradabad, Uttar Pradesh, India

**Corresponding Author:** Nishita Garg, Department of Pedodontics & Preventive Dentistry, Dental Institute, Rajendra Institute of Medical Sciences (RIMS), Ranchi, Jharkhand, India, Phone: +91 7060774863, e-mail: doctornish2210@gmail.com

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Digit ratios are determined in utero by about the 14th week,[15,17,18] and individual variability is established, which remains stable postnatally. Thus, it was hypothesized that 2D:4D could be utilized to assess the action of prenatal sex hormones in the development of taste perception, which is related to caries experience. Studies by Verma et al.[12] and Lakshmi et al.[13] have indicated a positive connection between low 2D:4D ratio and high caries index, proving this ratio as an uncomplicated, noninvasive chair-side method for easy recognition of high caries risk individual.

Identifying children with higher caries risk has significant implications for adult oral health. Fung et al.[19] suggested that ECC may be an early indicator of the progression of caries in the future, so prevention may lead to a reduction in caries prevalence in adults. To the best of our knowledge, the literature lacks enough evidence on the contrast of the relationship between severe ECC, food preferences, and hormonal fingerprints. Hence, the present study was conducted to evaluate the connection between severe ECC, food preferences, and 2nd digit–4th digit (2D:4D) ratio.

## Materials and Methods

The study protocol was reviewed and accepted by the Institutional Ethical Committee (EC) of the dental college. Detailed informed consent was received from parents or legal guardians of selected subjects about the research protocol and material being tested, allowing the inclusion of their children.

Out of a total of 1,267 children examined, 300 children in the age range of 3–6 years who satisfied the selection criteria were selected from both sexes. They were selected from various primary schools in Moradabad. These children were equally divided into group I, that is, caries-free group and group II, that is, caries group (those affected with S-ECC), consisting of 150 children in each group with 75 males and 75 females. The sample size was drawn after calculating the statistical power, which was 95% for this study.

Children who were uncooperative or had a medical history that affects salivary flow, taste sensation, or necessitated diet modification, undergoing any drug therapy 3 months before the study, with any known allergy/history of adverse reaction to PROP, wearing orthodontic appliance or with any injury in the fingers were disqualified from the research.

The methodology used in the preparation of strips of PROP was similar to that described by Zhao et al.[20] Whatman filter paper number three was cut into 3 × 1 cm size and sterilized. Commercially available tablets of PROP (PTU, 50 mg, Macleods Pharmaceuticals, Mumbai, India) were used to prepare a solution of PROP (1.6:1; drug:ethanol). About 1 mL of PROP solution was dispensed on each filter paper strip with the help of a pipette and allowed it to soak the solution. All the prepared PROP strips were dried at room temperature in a laminar chamber. Only those strips with a difference of 1.6–2.0 mg in their weights were selected for the study and sealed in sterilized pouches individually and stored in a dry place until use.

A single trained and calibrated examiner (S.S) conducted all the oral examination for the presence or absence of caries. An assistant recorded the findings on a predetermined proforma. The presence of dental caries was recorded using the deft index for primary teeth as given by Gruebbel.[21] Dental examinations of the children were conducted under good illumination and with the help of a mirror and explorer.

Children were asked to abstain from consuming any food or liquid 120 minutes prior to the PROP test. The prepared PROP strip was placed on the dorsum of the tongue in the anterior two-thirds region for 30 seconds. The children were questioned about its taste after 30 seconds, and if their answer was no or if they reported that it had a paper-like taste, they were considered nontasters.[9] If the children felt a bitter taste, they were differentiated as tasters.[9] If the children were not sure about the taste or were confused, they were retested later in the next appointment.

The 2D:4D ratio was recorded by measuring the index and ring finger length of the hand (ventral surface) from the basal crease of finger to the tip of the finger with the aid of electronic digital caliper. In cases where there are several creases at the finger base, measurements from the most proximal crease to the tip of the finger were obtained. The digit ratio was calculated by dividing the length of 2nd digit by that of the 4th digit. The subjects and controls were further divided according to their digit ratio:

- Low 2D:4D; ratio <1.
- Equal 2D:4D; ratio =1.
- High 2D:4D; ratio >1.

The parents or caretakers of all the subjects were then asked to fill out a questionnaire, which was designed to obtain information regarding food habits and preferences. The daily nutritional habits were recorded by a 3-day diet chart and analyzed for their sweet preference and cariogenic potential by recording sugar score, frequency of intake, and total sugar exposure (TSE). Parents or caretakers were requested to document the diet consumed by children during the day along with toffees/chocolates, in-between meals, or even sweetened medicinal syrup. The cariogenicity of all the items consumed was distributed into three types—(1) liquid, (2) solid and sticky, and (3) slow dissolving. Some Indian food items entered in the nutrition chart were included, and TSE was calculated. The frequency of food intake was multiplied by 5×, 10×, and 15×, respectively. A sugar score of <5 as excellent, with a score of =10 as good and a score of >15 as watch-out zone was considered. A 3-day average was obtained, which gave the mean TSE per day. Those children in the watch-out zone were grouped into sweet likers, and others were considered sweet dislikers.

### Statistical Analysis

The analysis of the obtained data was done using Statistical Package for Social Science (SPSS) Software version 17 for Windows. The comparison of caries experience (deft), 2D:4D ratio (hormonal fingerprint), and food preference was carried out using Pearson's Chi-square analysis and one-way analysis of variance (ANOVA).

## Results

Table 1 represents group-wise distribution of the study population according to PROP sensitivity test. The variation between caries-free and caries group pertaining to tasters and nontasters was found to be statistically highly significant ($p < 0.001$) and without any gender variation (data not shown). Table 2 represents group-wise distribution of the study population according to 2D:4D ratio and caries experience. There was a statistically significant difference in 2D:4D ratio between caries-free and caries group ($p$-value = 0.004). High 2D:4D ratio was seen most commonly among caries group, whereas equal 2D:4D ratio was observed among caries-free group, while the low 2D:4D ratio was equally distributed in both groups and also without any gender variation in the distribution (data not shown). Table 3 represents the group-wise distribution of study population according to food preference. Out of 150 children in caries-free group, 126 children

**Table 1:** Distribution of the study population according to PROP sensitivity test

| | *PROP sensitivity test* | | | | |
|---|---|---|---|---|---|
| *Group* | *Nontasters* | *Tasters* | *Total* | *Pearson's Chi-square* | |
| Caries-free | 23 (15.3%) | | 150 (100%) | Value | Degree of freedom |
| Caries | 121 (80.7%) | | 150 (100%) | 128.3 | 1 |
| Total | 144 (48.0%) | | 300 (100%) | $p < 0.001$ (significant) | |

**Table 2:** Distribution of the study population according to 2D:4D ratio and caries experience

| | *2D:4D ratio* | | | | | |
|---|---|---|---|---|---|---|
| *Group* | *Low (<1)* | *Equal (=1)* | *High (>1)* | *Total* | *Pearson's Chi-square* | |
| Caries-free | 129 (86.0%) | 13 (8.7%) | 8 (5.3%) | 150 (100%) | Value | Degree of freedom |
| Caries | 122 (81.3%) | 5 (3.3%) | 23 (15.3%) | 150 (100%) | 11.002 | 2 |
| Total | 251 (83.7%) | 18 (6.0%) | 31 (10.3%) | 300 (100%) | *p*-value | |
| | | | | | 0.004 (significant) | |

**Table 3:** Group-wise distribution of study population according to food preference

| | *Food preference* | | | | |
|---|---|---|---|---|---|
| *Group* | *Sweet dislikers* | *Sweet likers* | *Total* | *Pearson Chi-square* | |
| Caries-free | 126 (84.0%) | 24 (16.0%) | 150 (100%) | Value | Degree of freedom |
| Caries | 8 (5.3%) | 142 (94.7%) | 150 (100%) | 187.8 | 1 |
| Total | 134 (44.7%) | 166 (55.3%) | 300 (100.0%) | *p*-value | |
| | | | | <0.001 (significant) | |

**Table 4:** Distribution of children in caries-free group according to PROP sensitivity test, 2D:4D ratio, and food preference

| | | | *Food preference* | | |
|---|---|---|---|---|---|
| *PROP sensitivity test* | | | *Sweet dislikers* | *Sweet likers* | *Total* |
| Nontasters | 2D:4D ratio | Low (<1) | 14 | 5 | 19 |
| | | | 73.7% | 26.3% | 100.0% |
| | | Equal (=1) | 0 | 1 | 1 |
| | | | 0% | 100% | 100% |
| | | High (>1) | 2 | 1 | 3 |
| | | | 66.6% | 33.3% | 100% |
| | | Total | 16 | 7 | 23 |
| | | | 69.6% | 30.4% | 100.0% |
| Tasters | 2D:4D ratio | Low (<1) | 97 | 13 | 110 |
| | | | 88.2% | 11.8% | 100.0% |
| | | Equal (=1) | 8 | 4 | 12 |
| | | | 66.7% | 33.3% | 100.0% |
| | | High (>1) | 5 | 0 | 5 |
| | | | 100% | 0% | 100.0% |
| | | Total | 110 | 17 | 127 |
| | | | 86.6% | 13.4% | 100.0% |

(84%) were sweet dislikers and 24 children were sweet likers. In caries group, eight children (5.3%) were sweet dislikers and 142 children were sweet likers. The disparity observed between the groups was statistically significant at $p < 0.001$. Table 4 shows the distribution of children in caries-free group according to PROP sensitivity test, hormonal fingerprint, and food preference. Majority of children in caries-free group are sweet dislikers, and there is no significant difference observed among tasters ($p = 0.077$) and nontasters ($p = 0.294$). The comparison of mean sweet score among low, equal, and high 2D:4D ratio populations in caries-free group using one-way ANOVA revealed no differences between the groups ($p > 0.05$) (data not shown). The mean sweet score is below "10," indicating that all the children are in the "good" zone. Majority of children in caries group are sweet likers, and there is no significant difference observed among tasters (*p*-value = 0.538) and nontasters (*p*-value = 0.910) (data not shown). Comparison of mean sweet score among low, equal, and high 2D:4D ratio populations in the caries group using one-way ANOVA. There were no discrepancies between the groups ($p > 0.05$). The mean sweet score of all the participants is >15, indicating that all the children are in the "watch-out" zone (data not shown).

## Discussion

Taste preferences have been found to have a significant effect on eating behaviors and are influenced by taste perception. Bitterness and sweet taste perception vary depending on one's genes. The two substances, phenylthiocarbamide (PTC) and PROP have been used to determine genetic sensitivity to bitter taste.[22,23] These chemicals taste bitter to about 75% of humans who are classified as "tasters." The rest of the population finds them tasteless and are considered "nontasters."[24] The percentage of nontasters differs between populations across the globe, ranging from 3% in West Africa to 23% in China. In India, it has been observed to be as high as 40%. In Caucasian North American populations, nontaster frequency is about 30%.[9,25] In this research, PROP nontasters were 48%, and tasters were 52%, consistent with one done by Verma et al.,[10] Pidamale et al.,[8] and Lakshmi et al.,[13] and inconsistent with the results found by Rupesh et al.[26] where there were 19.5% nontasters and with Hegde et al.[2] where the percentage of nontasters was 26.

Various researchers have claimed that those children who are sensitive toward bitter taste might have an association with the acceptance or rejection of some food items. Anliker et al.[7] was the pioneer who assessed the connection between PROP taste and food acceptance in children aged <7 years. Fischer et al.[27] and Glanville et al.[28] reported that subjects with lower thresholds for PROP (higher sensitivity) displayed more food aversions compared to those with higher thresholds (lower sensitivity), who preferred strong-tasting foods. Ullrich et al.[29] stated that supertasters who are sweet dislikers do not like sweet food because their perception for various sensation is too severe and, therefore, are less prone to agree to the intensely bitter-sweet substance, making them less prone to caries. In the present study, it was observed that most numbers of nontasters are sweet likers, whereas the tasters were sweet dislikers. This is in accordance with the findings by Mennella et al.,[30] who reported that taster children showed an increased sweet sensitivity, liking, and consumption, while their mothers had no relation to sweet preference. Studies by Verma et al.[10] and Keller et al.[31] have shown an increased liking for sweet food by tasters. In contrast, Keller and Tepper[32] and Keller et al.[33] reported that PROP taster phenotype is associated with a greater intake of sweets foods and beverages by children.

Children with a high density of fungiform papillae have a greater propensity to experience sensations from taste to some oral somatosensory stimuli[34–36] and, thus, PROP tasters may display greater densities of trigeminal fibers (touch) on the tongue than nontasters. This explains why PROP tasters exhibit a higher perception of sweetness from sucrose to saccharine. So, nontaster children may consume higher concentrations and frequencies of sugars in comparison to children who are supertasters/medium tasters and are, therefore, more prone to dental caries. Lin[37] evaluated the prevalence of dental caries among different genetic sensitivity levels of taste and suggested an increased overall caries experience in nontaster children. Rupesh et al.[26] in their study stated that dental caries experience was highly significant to nontasters. They suggested sweet likers were nontasters and favored strong-tasting food items. Hegde et al.[2] reported that higher caries experience was associated with nontaster children, supertasters preferred to be dislikers of sweet and fatty food, and nontasters were likers. Pidamale et al.[8] observed higher decayed, missing, and filled surfaces (dmfs) score in nontaster children than taster children and concluded that tasters tended to be sweet dislikers and nontasters to be sweet likers. In this study, the prevalence of nontasters was high in caries group. The data recorded in this study supports their findings. The majority of children in caries group were nontasters who were proved to be sweet likers (86%).

Observations by Manning et al.,[18] Lutchmaya et al.,[38] and McIntyre et al.[39] have suggested that 2D:4D ratio of the right hand is more responsive to hormonal ratio, and hence in the present study, all measurements were recorded for the right hand only. In previous research, photocopies of left and right hands were recorded to assess digit length measurement.[40,41] This method produced data that correlated with those scored directly from the hands with caliper[42] and gave lower 2D:4D ratios with better interobserver reliability.[43] However, photocopies may deform left- and right-hand asymmetries; therefore, in the present study, direct measurements from hands were obtained. The observations of the present study are similar to Manning et al.[44] and Verma et al.[12] Results of the study by Verma et al.[12] suggested a significant correlation between low 2D:4D and high caries index in an Indian population. Lakshmi et al.[13] have reported a strong correlation between low digit ratio, sweet likers, nontasters, and a high caries index. The authors have recommended the use of 2D:4D as a simple, noninvasive chair-side procedure for early detection of individuals with high caries risk.

In general, mean 2D:4D has been found to be smaller in men compared to women, as in males, the 2nd digit has a tendency to be smaller than the 4th, and in females, the 2nd has a tendency to be the equal size or a little higher than the 4th.[15] This characteristic is illustrated as "sexually differentiated" rather than "sexually dimorphic" in accordance to the fact that the effect size is small and 2D:4D distribution of the two genders overlap to a great extent, especially in comparison to other sexually dimorphic characters for example height.[42] In this study, majority of the male children displayed low 2D:4D ratio compared to females, but the difference was not statistically significant.

Majority of the children allocated to the caries group were nontasters, sweet likers, and had low 2D:4D ratios, but low 2D:4D ratio was observed in caries-free group also. There is no straightforward 1:1 correlation between 2D:4D ratio and S-ECC observed in the present study. The results of this research demonstrate that 2D:4D ratio in relation to S-ECC should further be explored by taking other influencing factors into consideration before arriving at a definitive conclusion.

## Orcid

*Nishita Garg* https://orcid.org/0000-0001-6594-9098
*Ramakrishna Yeluri* https://orcid.org/0000-0002-0320-2105

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