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Assessment of association between Salivary Alpha Amylase, Buffering capacity, dmft index, BMI and Socioeconomic Status in children with and without Early Childhood Caries- An analytical study

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ABSTRACT

Objectives:Early Childhood Caries is one of the most common chronic conditions in preschool-aged children. Salivary components such as alpha-amylase (sAA) and buffering capacity help maintain oral health by controlling pH and influencing microbial activity. Body Mass Index (BMI), and socioeconomic status (SES) may further impact caries risk. This study evaluated the associations between sAA, buffering capacity, BMI, SES, and dmft scores in children with and without ECC.

Methods:A total of 78 children aged 3-6 years participated. Based on caries experience, they were categorized into an ECC group (n=39) and a caries-free group (n=39). The ECC group was further divided into three subgroups by dmft score: A (0-5), B (6-10), and C (≥11). BMI percentiles were determined using CDC growth charts, while SES was assessed using the Modified Kuppuswamy Scale (2017). Unstimulated saliva collected; sAA was quantified using ELISA, and buffering capacity was determined by titrating with 0.01 N HCl and measuring pH changes. Statistical analysis included descriptive measures and Pearson's correlation.

Results:Mean dmft values rose progressively across ECC subgroups: A (3.08 ± 0.76), B (8.38 ± 1.25), C (15.46 ± 2.88). Higher BMI was observed with greater caries severity, with overweight more common in Group C. Lower SES was linked to a higher dmft. Buffering capacity decreased as dmft increased, ranging from normal in Group A (3.62 ± 0.51) to low in Group C (1.62 ± 0.96). Mean sAA levels followed a similar declining pattern, from 2.9 ± 1.8 in Group A to 2.2 ± 1.2 in Group C. Correlation analysis showed strong positive association between dmft and BMI (r=0.646), strong negative association between dmft and buffering capacity (r=-0.708), and moderate negative association between BMI and buffering capacity (r=-0.409).

Conclusion:Greater ECC severity was linked to higher BMI, reduced salivary buffering capacity, and lower sAA levels, with socioeconomic amplifying the risk. Assessing salivary markers alongside BMI and SES may enable early identification of children at elevated risk and support timely preventive strategies

Keywords: Early Childhood Caries, Body Mass Index, Buffering Capacity, Salivary Alpha Amylase, Socioeconomic Status

1. INTRODUCTION

Dental caries in primary teeth ranks as the 12th most common disease worldwide, impacting approximately 560 million children globally [1]. The American Academy of Pediatric Dentistry defines Early Childhood Caries (ECC) as the presence of one or more decayed (cavitated or non-cavitated), missing (due to caries), or filled tooth surfaces in any primary tooth of a child aged 71 months or younger [2].

Saliva plays a crucial role in maintaining oral health. Unstimulated saliva is continuously secreted into the oral cavity, contributing to various essential functions including digestion, lubrication, immune defence, buffering capacity, pH maintenance, and supporting speech and swallowing.The dmft index (decayed, missing, and filled teeth) is a widely accepted numerical tool for evaluating dental health in primary dentition. It provides insight into the oral health status of children within specific populations and remains a standard metric globally [3]. Body Mass Index (BMI), which is a measure derived from a person's weight and height, has been shown to have a direct correlation with dental caries risk [4].

Additionally, socioeconomic status (SES) is recognized as a significant risk factor in the development and progression of dental caries. An inverse association has been observed between SES and the prevalence of ECC, with children from lower socioeconomic backgrounds demonstrating a higher incidence of the condition [5,6]. Salivary buffering capacity, primarily facilitated by the bicarbonate buffering system, plays an essential role in maintaining oral pH. Research by Ericson and Makinen supports an inverse correlation between buffering capacity and caries activity, indicating its significance in assessing caries risk [7].

Among the components of saliva, salivary α-amylase (sAA) stands out, comprising about 10-20% of total salivary proteins [8]. It is secreted mainly by the acinar cells of the parotid glands [9], and plays a key role in carbohydrate digestion by breaking down starch into glucose and maltose [10]. Furthermore, sAA is thought to affect taste, hunger, and food texture perception, and may potentially influence an individual's preference for sugar-rich foods. Thus, evaluating sAA levels may offer insights into a person's predisposition toward sugary dietary choices.

In summary, dental caries is a multifactorial and dynamic condition, influenced by a range of biological, behavioral, and socioeconomic factors. This study aims to evaluate the relationship between salivary α-amylase levels, buffering capacity, dmft index, BMI, and socioeconomic status in children with and without ECC.

2. METHODOLOGY

Ethical Approval and Study Setting.

The study was approved by the Institutional Ethical Committee of Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital (BVDU DCH), Pune, India, under approval number (EW/NEW/INST/2021/MH/0029). The research was conducted on pediatric patients attending the Outpatient Department of Pediatric and Preventive Dentistry at Bharati Vidyapeeth Dental College and Hospital, Pune. This was a cross-sectional analytical study comparing relationship between salivary α-amylase levels, buffering capacity, dmft index, BMI, and socioeconomic status in children with and without ECC

Sample Selection.

A sample size of 78 children, aged between 3 to 6 years, was determined for the study while Children who were medically unfit or uncooperative were excluded from the study. Participants were divided into two groups:

Group I (n = 39): Children diagnosed with Early Childhood Caries (ECC), having one or more decayed, missing (due to caries), or filled teeth.Based on individual dmft scores, children in Group I were subdivided into three subgroups: Subgroup A: dmft score 1-5; Subgroup B: dmft score 6-10; Subgroup C: dmft score ≥11 with each group consisting of 13 children.

Group II (n = 39): Children who were caries-free.

A consent letter outlining the aim and objectives of the study was provided to the parents or guardians of all participants. Prior to saliva collection, parents were instructed to ensure that the child did not consume any food for at least one hour. This was followed by a comprehensive case history recording.

Anthropometric Assessment and BMI Calculation.

Each child's height was measured in meters and weight was recorded using a calibrated digital weighing scale. The Body Mass Index (BMI) was calculated using the formula: BMI= kg/m^2. (Fig. 1)

Children were measured without shoes, standing upright with heels together and head aligned horizontally.Using the calculated BMI scores, age-specific BMI percentiles were determined with reference to the Centers for Disease Control and Prevention (CDC) growth charts. Based on percentile ranges, children were classified into the following categories: Underweight; Normal weight; At risk of overweight; Overweight.(Fig. 1)

Saliva Sample Collection and Laboratory Analysis.

Unstimulated saliva samples were collected from each child. A 1 mL aliquot of the sample was transferred to the Interactive

Research School for Health Affairs (IRSHA), Pune for ELISA-based estimation of salivary alpha-amylase (sAA) levels.The samples were centrifuged at 300 rpm for 10 minutes and stored at -82°C until analysis. (Fig. 1)

Buffering Capacity (BC) of Saliva.

The remaining portion of the saliva sample was used to evaluate salivary buffering capacity. This was done by mixing: 1 mL of saliva with 3 mL of 0.01 N hydrochloric acid (HCl). The mixture was stirred manually and allowed to stand in an open container for 10 minutes to allow CO_2 to escape. The final pH of the solution was measured using a pre-calibrated portable digital pH meter. (Fig. 1)

Based on the pH values, buffering capacity was categorized as:

Normal BC: pH 5.0 to 7.0

Borderline BC: pH 4.0 to 5.0

Low BC: pH below 4.0

Figure 1. A- Diagnostic instruments, B & C- Height and Weight measuring scale, D- BMI range, E- Elisa kit[krishgen biosystem human Alpha amylase testing ELISA kit], F- wells for ELISA, G- Digital pH meter, H- Kuppuswamy Scale for SES

Data Compilation and Statistical Analysis

All data and recorded parameters were systematically compiled, tabulated, and subjected to statistical analysis to derive the study results.

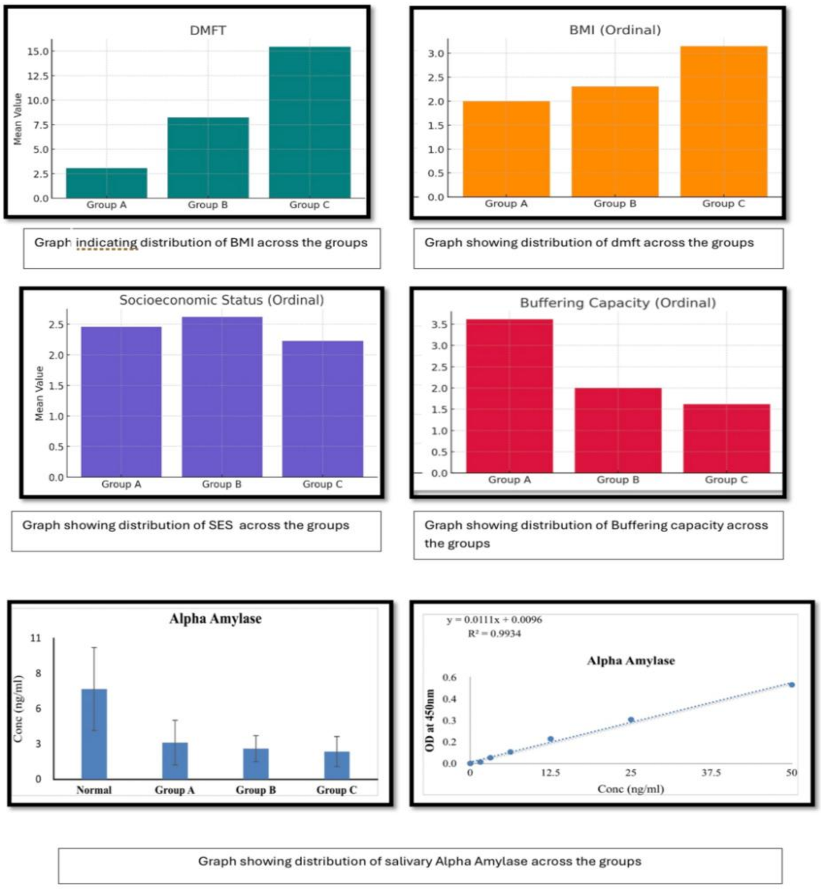
3. RESULTS

The results reveal distinct trends across the three subgroups of children with varying severities of early childhood caries (ECC), classified by their dmft (decayed, missing, and filled teeth) scores. (Table. 1) (fig.2)

Table1 : Comparison of Mean Values Across ECC Severity Groups

Parameter	Group A (dmft 0–5)	Group B (dmft 6–10)	Group C (dmft 11–20)
dmft(Mean ± SD)	3.08 ± 0.76	8.23 ± 1.24	15.46 ± 2.88
BMI (Mean ± SD)	2.00 ± 0.58 (Predominantly	2.31 ± 0.85 (Normal/Overweight)	3.15 ± 0.80 (Overweight/Obese)

	Normal)		
SES (Mean ± SD)	2.46 ± 0.88 (Lower to Upper Middle)	2.62 ± 0.77 (Lower to Upper Middle)	2.23 ± 0.83 (Primarily Lower Middle)
Buffering Capacity (Mean ± SD)	3.62 ± 0.51 (Predominantly Normal)	2.00 ± 1.00 (Low to Borderline)	1.62 ± 0.96 (Predominantly Low)
Salivary Alpha Amylase (Mean ± SD)	2.9 ± 1.8(normal)	2.4 ± 1.1(low to boderline)	2.2±1.2(Predominantly Low)



Graph indicating distribution of BMI across the groups

Graph showing distribution of dmft across the groups

Graph showing distribution of SES across the groups

Graph showing distribution of Buffering capacity across the groups

Graph showing distribution of salivary Alpha Amylase across the groups

Figure 2: Graphs of distribution of parameters across the groups.

dmft Scores

There was a progressive and statistically significant increase in dmft scores across the subgroups. Group A (mild ECC) had the lowest mean dmft value (Mean = 3.08), while Group C (severe ECC) exhibited the highest (Mean = 15.46). This trend confirms the validity of the subgrouping and reflects an escalating caries burden with increasing ECC severity.

Body Mass Index (BMI)

BMI values were found to rise in tandem with caries severity. Group A participants largely fell within the normal BMI range (Mean = 2.00), whereas children in Group C showed elevated BMI values (Mean = 3.15), with a greater proportion classified as overweight or obese. These findings indicate a potential positive association between increased BMI and caries prevalence, possibly mediated by common lifestyle and dietary factors.

Socioeconomic Status (SES)

Although the overall distribution of SES was not significantly different between groups, Group C tended to comprise children from lower socioeconomic backgrounds (Mean SES score = 2.23). While not statistically significant, this trend suggests that lower SES may contribute to higher ECC risk, potentially due to limited access to oral healthcare, suboptimal nutrition, and reduced oral hygiene awareness.

Salivary Buffering Capacity

A marked decline in salivary buffering capacity was observed with increasing dmft scores. Children in Group A had the highest mean buffering capacity (Mean = 3.62), with most falling in the "Normal" range. In contrast, Group C demonstrated significantly reduced buffering capacity (Mean = 1.62), predominantly in the "Low" range. These results support the hypothesis that reduced salivary buffering is strongly associated with elevated caries risk.

Salivary Alpha-Amylase (sAA)

An inverse correlation was noted between salivary alpha-amylase levels and dmft scores. Group A showed the highest mean sAA levels (Mean = 2.9), while Group C recorded the lowest (Mean = 2.2). These findings suggest that lower sAA activity may be associated with greater caries experience, possibly due to its role in starch metabolism and oral microbial ecology.

***Table 2: Pearson correlation* matrix between dmft, BMI, SES, and buffering capacity (BC)**

	dmft	BMI	SES	BC
DMFT	1.000	0.646	-0.180	-0.708
BMI	0.646	1.000	0.099	-0.409
SES	-0.180	0.099	1.000	0.304
BC	-0.708	-0.409	0.304	1.000

The numbers inside each box represent the Pearson correlation coefficient (r), (table 2, Figure 3)

• +1 = perfect positive correlation

• -1 = perfect negative correlation

• 0 = no correlation

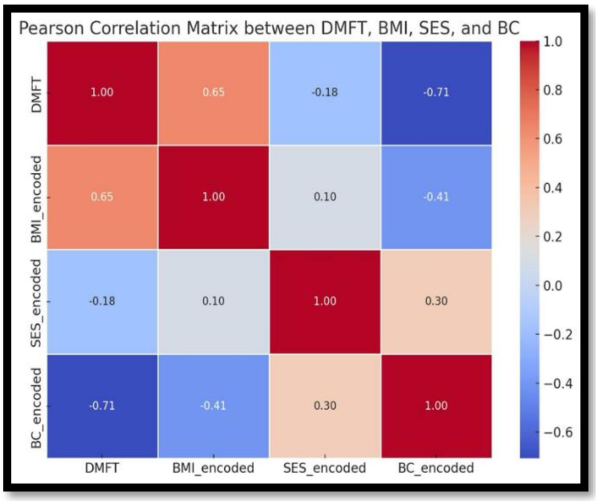


Figure 3: Thermal Diagram of correlation

4. DISCUSSION

The term Early Childhood Caries (ECC) was introduced in 1994 during a workshop hosted by the Centers for Disease Control and Prevention, with the intent to emphasize the multifactorial etiology of caries in young children. Rather than attributing ECC solely to inappropriate feeding practices, the terminology shifted focus to the broader influences of socioeconomic, behavioral, and psychosocial factors [11]. Nonetheless, terms such as “nursing caries” are still used in some literature to denote feeding-related causation, reflecting the historical perspective. The prevalence of ECC in India remains alarmingly high. National surveys have reported that approximately 44-49% of children aged between 8 to 48 months are affected [12]. A meta-analysis by Pandey et al. (2021) reported an overall dental caries prevalence of 54.16%, with the rate increasing to 57% in children aged 3-18 years [13]. Similarly, Deven et al. (2022) highlighted that nearly one in two preschool children in India experience ECC [14]. Regional disparities are evident, with most studies concentrated in Southern India, particularly Karnataka, while regions like Central and Eastern India remain under-researched but exhibit notably high ECC rates (up to 60.2%) [15].

Body Mass Index (BMI) and ECC

In this study, a clear trend emerged linking higher BMI values with greater caries severity. Children in the highest caries group (dmft $\geq$ 11) demonstrated significantly elevated BMI levels compared to caries-free peers. These findings are consistent with those of Willershausen et al. (2007), who observed a higher caries incidence among overweight children [16]. Supporting this, a systematic review by Hooley et al. (2012) identified a positive correlation between obesity and dental caries, particularly in environments with high sugar consumption [17]. Alm et al. (2008) similarly reported that children with elevated BMI had increased ECC risk, likely due to lifestyle habits such as frequent snacking and poor dietary quality [18].

The present findings support the hypothesis that shared risk factors, particularly high intake of fermentable carbohydrates, underlie both obesity and dental caries.

Socioeconomic Status (SES)

Socioeconomic status remains a pivotal determinant of oral health. Numerous studies have shown that children from lower SES backgrounds are at significantly higher risk for ECC due to factors such as increased sugar exposure, infrequent dental visits, and limited health education [19]. Although the current study did not find a statistically significant association between SES and ECC prevalence, a trend was observed wherein children from lower SES backgrounds had a higher caries burden. This partial alignment with findings from studies by Priyadarshini (2021) [19], Das (2022) [20] and James [21] may be influenced by variables such as a limited sample size, regional differences, or uniform access to preventive services across SES groups within the study population.

Salivary Buffering Capacity

Saliva plays a critical role in maintaining oral health by buffering acidic by-products of bacterial metabolism. The bicarbonate-carbonic acid and phosphate systems are central to this neutralizing function, as noted by Stephen (1997) and several investigations, including those by Alamoudi (2004) and Cogulu (2006), have emphasized the importance of buffering capacity in protecting enamel surfaces from demineralization [22,23,24]. Tenovuo (1998) further reinforced the significance of this mechanism in caries prevention [25]. In the present study, children with higher caries scores demonstrated significantly lower salivary buffering capacities, particularly those in Group C (dmft $\geq$11), who exhibited predominantly low buffering values. These findings are consistent with earlier studies by Aykut-Yetkiner (2014) [26], Preethi (2010) [27], and Mutneja (2011) [28] and Papas AS [29], all of which found an inverse relationship between buffering capacity and caries incidence. Reduced buffering impairs the saliva’s ability to neutralize acids, creating a favorable environment for enamel demineralization and lesion progression.

Salivary Alpha-Amylase (sAA)

Salivary alpha-amylase (sAA) is a key enzyme responsible for initiating the digestion of starches into fermentable sugars such as maltose and glucose. Beyond its digestive role, sAA has emerged as a potential biomarker for caries risk, particularly due to its influence on microbial adhesion and acid production. While some literature has reported elevated sAA levels in children with active caries [30-32], the present study observed a decline in sAA levels with increasing caries severity. Children in the highest dmft group exhibited the lowest mean sAA concentrations, contrasting findings from studies such as Menezes et al. (2021) [30] and Patil et al. (2022) [31], which noted higher sAA levels in caries-active individuals.

5. CONCLUSION

The results of this study reinforce the multifactorial etiology of ECC, implicating a complex interplay of nutritional status, biological protective mechanisms, and socioeconomic influences. Specifically: Higher BMI was positively associated with ECC severity; Lower salivary buffering capacity strongly correlated with higher caries scores; Reduced alpha-amylase levels may be linked to diminished oral protective responses; although not statistically significant, lower SES showed a trend toward higher caries burden.

These findings suggest that prevention and management strategies for ECC must adopt an integrated approach, addressing dietary patterns, improving awareness across socioeconomic groups, and considering salivary biomarkers in risk assessment protocols

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