Evaluation of salivary characteristics as a contributory factor in children with early childhood caries (ECC)

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Abstract

Background: Early Childhood Caries (ECC) is a severe and widespread oral health issue that affects children's primary teeth soon after eruption, with high prevalence in both developing and some developed countries. Saliva plays a critical protective role against dental caries through its flow rate, pH, and buffering capacity, which influence plaque formation, acid neutralization, and enamel remineralization. Despite external factors like feeding habits and hygiene, endogenous salivary factors may explain why some children develop ECC while others do not. Understanding and evaluating these salivary characteristics is essential for effective ECC prevention and management.

Aim: The aim of this study was to evaluate salivary characteristics as a contributory factor in children with ECC.

Materials and Methods: This comparative cross-sectional study was conducted over one year at the University of Dental Medicine (Mandalay) and selected schools in Mandalay, involving 120 children aged 71 months and younger, categorized into ECC and caries-free groups. Salivary parameters including flow rate, pH, and buffering capacity were assessed using the GC Saliva Check Buffer Kit. Children were selected through random sampling, and ethical approval and informed consent were obtained in line with institutional guidelines.

Results: A total of 120 children (60 with ECC and 60 caries-free) participated, with more girls than boys, especially in the ECC group. The mean resting salivary pH, buffering capacity, and stimulated salivary flow rate were slightly higher in the caries-free group compared to the ECC group; however, none of these differences were statistically significant ($p > 0.05$). There was no significant correlation between salivary flow rate and pH or buffering capacity in either group. However, a statistically significant positive correlation was found between buffering capacity and salivary pH in both ECC ($r = 0.258$, $p = 0.04$) and caries-free children ($r = 0.275$, $p = 0.033$), indicating that as buffering capacity increased, pH levels also tended to be higher.

Discussion and Conclusion: This study found that while salivary characteristics such as pH, buffering capacity, and flow rate were generally higher in caries-free children than in those with ECC, none showed a statistically significant difference or strong correlation with caries activity. A weak association was noted between buffering capacity and salivary pH, but no significant relationships were found between flow rate and either pH or buffering capacity. Therefore, salivary parameters alone may not be reliable indicators for ECC risk prediction, and further research with larger sample sizes and additional variables is recommended.

Keywords:ECC, Salivary pH, buffering capacity, flow rate, caries risk assessment

Introduction

Oral health problems or illnesses can influence the general development of a child, and its general health can adversely affect the quality of life. Dental caries in infants and toddlers is now collectively known as ECC. “ECC is a devastating form of caries that may affect the primary dentition as soon as infant’s teeth erupt”

(Huntington, Kim and Hughes, 2002)[1]. There has been a reduction in dental caries prevalence in children from industrialized countries, and an increase in several developing countries" (Petersen, 2003)[2]. Dye's (2007) "Trends in oral health status: United States, 1988-1994 and 1999-2004" indicates ECC is a world-wide major health problem and affects 28% of US children (Lawrence, 2012)[3].

In Lao PDR, 6-year-old children 67.3% had dental caries in primary teeth according to the 1991 first National Oral Health Status Survey. Oral health surveys of 5-year-old and 6-year-old pre-school children in Malaysia showed a high caries prevalence of 76.2% and 74.5% in 2005 and 2007 respectively (Oral Health Division, 2009). In Myanmar, prevalence of dental caries in preschool children was 72.44% and mean dmft was 5.82 (Win, 1994) [4]. In 2006-2007, 5 years old children 74.78% had dental caries in primary teeth according to Pathfinder Oral Health Survey in Myanmar. ECC is a multi-factorial disease that involves a susceptible tooth and host, fermentable carbohydrates in the diet, cariogenic micro-organisms and time. While there are many potential causes of ECC, one of the most important factors is host factor which is salivary factor that plays a role in protecting dental caries.

Saliva has an important impact, through functions relying on physiochemical characteristics such as flow rate, pH and buffering capacity, so variations under threshold levels are considered risk factors for the development of dental caries. Mandel's (1974) "relation of saliva and plaque to caries" indicates theoretically, saliva affects the incidence of dental caries in four ways: (1) as a mechanical cleansing agent that results in less accumulation of plaque (2) by reducing enamel solubility by means of calcium, phosphate and fluoride (3) by buffering the neutralizing the acids produced by cariogenic organisms or introduced directly through the diet (4) by antibacterial activity (Animireddy, 2014)[5].

It has been reported that saliva can be used as a diagnostic tool for assessment of dental caries (Gopinath and Arzreanne, 2006)[6]. Kirstila (1998)[7] concluded that one of the major functions of human saliva is to protect dentition against dental caries. Yarat et al. (1999)[8] argued that saliva composition is an important factor in determining the prevalence of caries. Although inappropriate pattern of feeding, oral hygiene care and Streptococcus mutans infection are disease causing but they are not sufficient factors to initiate ECC. Endogenous factors, such as salivary characteristics may be an answer to this question that why some children develop ECC while others do not. The important aspects of saliva that plays in protecting against dental caries are flow rate, pH and buffering capacity.

The functions of the saliva include lubrication action which coats mucosa and also assists in speech and swallowing, and buffering capacity which helps to neutralize plaque pH after eating are more important for oral health. These actions can be modified by salivary pH which also plays a role in carious process. "Normal salivary pH is from 6 to 7 and varies in accordance with salivary flow, from 5.3 (low flow) to 7.8 (peak flow)" (Almeida et al., 2008) [9]. As the bicarbonate levels in saliva increase, this will not only increase salivary pH and buffering capacity and facilitate remineralization but will also exert ecological effects on oral flora. Salivary buffers can reverse the low pH in plaque and allow for oral clearance thus preventing demineralization of enamel. Salivary flow rate is important for the severity of the caries disease, and it should be considered as assessing caries risk. Andersson's (1974) "the flow rate, pH and buffer effect of mixed saliva in children" indicates salivary flow rate is lower among

younger children and lower among females than males (Adair, 1999)[10].

Since saliva provides a general protective effect, salivary characteristics contribute to the development of dental caries. If only conventional treatment done in the patients without changing the level of salivary parameters, recurrence of caries can be detected in a short time. In addition, there is a need to know the dmft values and many causative factors of ECC, whereas dentists can give preventive strategies for ECC children.

By constantly bathing the teeth and oral mucosa with saliva, it functions as a cleansing solution, lubricant, a buffer and ion reservoir of calcium and phosphate which are essential for re-mineralization of initial carious lesions (Preethi, Reshma and Anand, 2010) [11].The mean resting pH in caries free group was significantly higher than ECC group (Farsi, 2008)[12]. However, in some studies, salivary pH was similar between the two groups with different caries status (Thaweboon et al., 2008)[13]. Many studies discussed about salivary flow rate, pH, buffer capacity in relation to dental caries, but there are differences in obtaining results between the studies in different regions. Therefore, this present study is to evaluate salivary characteristics as a contributory factor in children with ECC.

Materials and methods

Study Population

120 Children aged 71 months and younger, attending at Department of Paediatric dentistry, University of Dental medicine (Mandalay) and Mandalay city region, Myanmar. The study was approved by the Ethical Committee, University of Dental Medicine (Mandalay), and informed consent was obtained from the guardians of all participants before the experiment, in accordance with institutional guidelines.

Materials and equipments

1. Oral examination set (mirror, explorer, excavator, tweezer)

2. GC saliva check buffer test kit (GC Corporation, Tokyo, Japan)

3. Each test kit contains – test strip for testing resting salivary pH, saliva container

4. Examination gloves

Inclusion criteria

Both boys and girls with ECC and caries free children must be healthy and cooperative with the age of 71 months and younger

Exclusion criteria

1. Physically and mentally handicapped children

2. Congenitally dental and craniofacial abnormalities

3. Children with uncooperative behaviour

4. Acute Infections of the oral cavity e.g. ulcers, cellulitis, viral infections

5. Children with disease condition (long term medication, underlying salivary gland disease, chronic illness)

Study procedure

Schools were randomly selected from Mandalay city, Myanmar. Subjects were randomized by two intervals from their class roll numbers. Selected children were screened for two groups. Those who are willing to participate in the study were screened according to selection criteria.

All the children were examined at Paediatric department of UDM and Mandalay city region. Children were collected according to simple random sampling method. Children were screened and 120 children were selected according to AAPD guidelines (2014)[14]. Selected

children were chosen for each grouping – ECC children and caries free children.

At the day of saliva sampling (one day after oral examination) the parents were asked to perform usual oral hygiene procedure after breakfast (1 hour and 30 min) before saliva collection and during this period children were not permitted to eat or drink (Kirstila et al., 1998)[15]. After being collected for each group, saliva tests were performed by using GC saliva check buffer kit (GC Corporation, Tokyo, Japan).

dmft and dmfs score were recorded (Klein, 1938)[16]. Standard precaution was used to prevent unnecessary cross infection for collection of sample materials. All samples were collected between 10 and 12AM. Saliva from the subjects were spitted into the sterile saliva container and pH test strip was dipped into the collected saliva container for 10 seconds and then was compared with colorimetric chart according to manufacturer's instruction of GC saliva check buffer kit. For the collection of stimulated saliva, the subject was asked to chew paraffin wax to stimulate the salivary flow. After 30 seconds, subjects expectorated saliva into spittoon and continued chewing for further 5 minutes. Saliva was collected in a collection cup at regular intervals of time. Total volume of saliva collected was noted and divided by 5 to obtain the stimulated flow rate of saliva in ml/min.

After collection, the stimulated saliva was dropped with pipette onto buffering test strip. Using a pipette, sufficient saliva was drawn into the collection cup, and one drop of saliva onto each of the test pads. Immediately turn the strips 90 degrees to soak up any excess on the absorbent tissue. This prevented excess saliva from swelling on the test pad and possibly affecting the accuracy of the test result. The test pads began to change colour immediately and after 2 minutes, the final results were recorded by adding the points according to the final colour of each pad.

Results

In this study, total number of children was 120 (45 boys and 75 girls) involved in this study. In ECC group, 15 boys and 45 girls while in caries free group, 30 boys and 30 girls were involved as presented in Table-1.a.

Group	Male	Female	Total
ECC	15	45	60
Caries Free	30	30	60
Total	45	75	120

Table 1. Subject personal data Table 1.a.

The age range was 3-6 years in this study and 6 years old subjects were the greatest in number. Age distribution of the two groups was shown in Table 1.b.

Group	3-4yrs	4-5yrs	5-6yrs	Total
ECC	-	1	59	60
Caries Free	1	1	58	60
Total	1	2	117	120

Table 1.b. Age Distribution

Group	Salivary pH				
	Max	Min	Mean	Range	SD
ECC children	7.60	5.60	6.89	2	0.55
Caries free children	7.60	5.80	6.88	2	0.57
P value	0.845				

Table 2. Comparison of salivary pH between ECC and caries free

Table 2 presents the mean resting salivary pH values for the ECC and caries-free groups. In the ECC group, the maximum and minimum pH values were 7.60 and 5.60, respectively, while in the caries-free group, they were 7.60 and 5.80. The mean resting salivary pH was slightly higher in the ECC group (6.89) compared to the caries-free group (6.88). However, the difference was not statistically significant ($p > 0.05$). These findings are also illustrated in Figure 1.

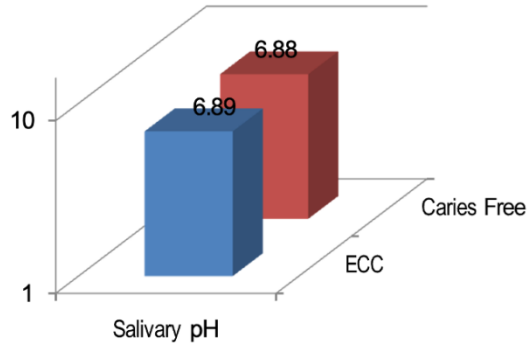

Figure 1. Comparison of salivary pH between ECC and caries free

Group	Buffering Capacity				
	Max	Min	Mean	Range	SD
ECC children	12	1	8.77	11	1.89
Caries free children	12	6	9.03	6	1.71
P value	0.419				

Table 3. Comparison of buffering capacity between ECC and caries free

Table 3 presents the mean buffering capacity values for the ECC and caries-free groups. In the ECC group, buffering capacity ranged from 1 to 12, while in the caries-free group, it ranged from 6 to 12. The mean buffering capacity was higher in the caries-free group (9.03) compared to the ECC group (8.77). However, the difference was not statistically significant ($p > 0.05$). These results are also illustrated in Figure 2.

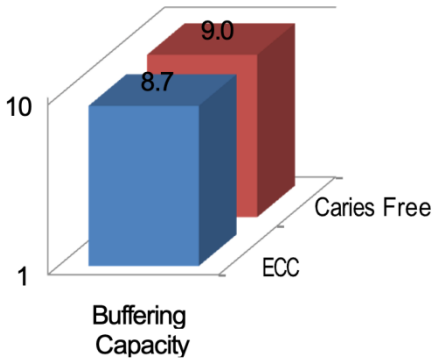

Figure 2. Comparison of buffering capacity between ECC and caries free

Group	Flow rate (ml/min)				
	Max	Min	Mean	Range	SD
ECC children	9	1	3.58	8	1.97
Caries free children	10	0.5	3.92	9.5	1.97
P value	0.356				

Table 4. Comparison of flow rate between ECC and caries free

Table 4 presents the mean stimulated salivary flow rate for the ECC and caries-free groups. In the ECC group, flow rates ranged from 1.0 to 9.0 mL/min, while in the caries-free group, they ranged from 0.5 to 10.0 mL/min. The mean stimulated salivary flow rate was higher in the caries-free group (3.92 mL/min) than in the ECC group (3.58 mL/min). However, this difference was not statistically significant ($p > 0.05$). A visual comparison of these results is presented in Figure 3.

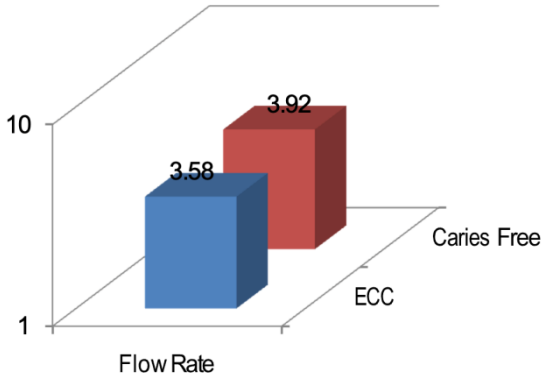

Figure 3. Comparison of flow rate of saliva between ECC and caries free

Group	Correlation of	r	p
Group A	Flow rate and Salivary pH	0.041	0.755
Group B	Flow rate and Salivary pH	-0.041	0.917

Table 5. Correlation between flow rate and salivary pH in each group, Group A-ECC group Group B-Caries-free group
* Pearson Correlation

Table 5 shows the relationship between salivary flow rate and resting salivary pH in each group. In the ECC group, the correlation coefficient (r = 0.041) indicated no significant association between flow rate and pH. Similarly, in the caries-free group, the correlation coefficient (r = –0.041) also suggested no meaningful relationship between these variables. These correlations are further demonstrated in Figure 4.a and b.

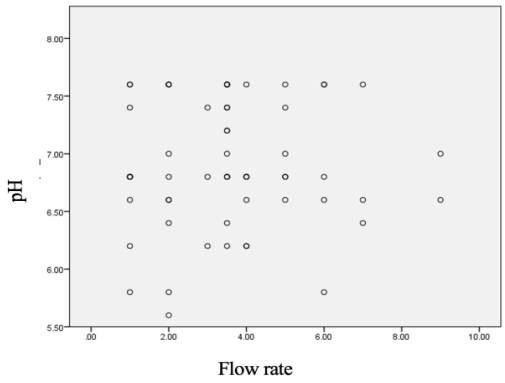

Figure 4.a Correlation between flow rate and salivary pH in ECC group

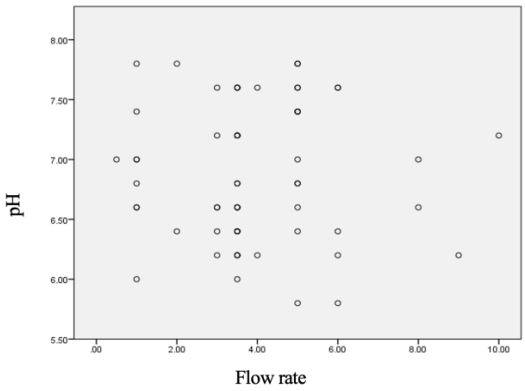

Figure 4.b. Correlation between flow rate and salivary pH in caries free group

Group	Correlation of	r	p
Group A	Buffering Capacity and Salivary pH	0.258	0.04
Group B	Buffering Capacity and Salivary pH	0.275	0.033

Table 6. Correlation between buffering capacity and salivary pH in each group

Table 6 presents the correlation between buffering capacity and resting salivary pH in each group. In the ECC group, the correlation coefficient (r = 0.258) indicated a weak positive association between buffering capacity and salivary pH. Similarly, in the caries-free group, a weak positive correlation was observed (r = 0.275). These correlations are depicted in Figure 5.a and b.

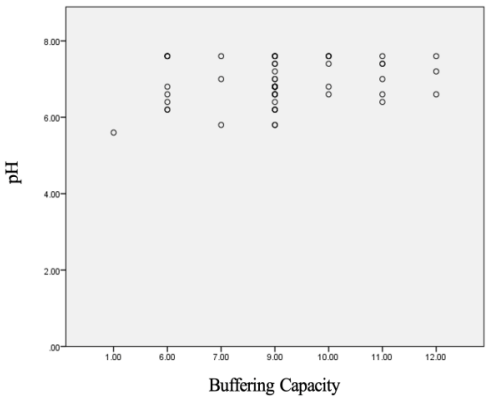

Figure 5.a Correlation between buffering capacity and salivary pH in ECC group

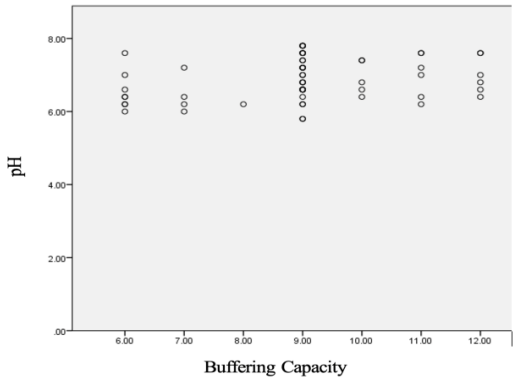

Figure 5.b Correlation between buffering capacity and salivary pH in caries free group

Group	Correlation of	r	p
Group A	Flow Rate and Buffering Capacity	0.174	0.184
Group B	Flow Rate and Buffering Capacity	0.225	0.083

Table 7. Correlation between flow rate and buffering capacity in each group

Table 7 shows the correlation between salivary flow rate and buffering capacity in each group. In the ECC group, the correlation coefficient (r = 0.174) indicated no significant association. Similarly, in the caries-free group, the

correlation coefficient (r = 0.225) also suggested no relationship between these variables. These correlations are illustrated in Figure 6.a and b.

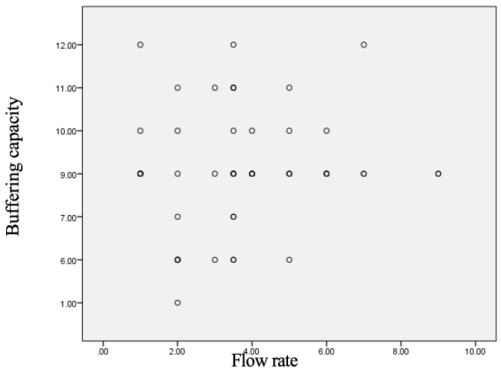

Figure 6.a Correlation between flow rate and buffering capacity in ECC group

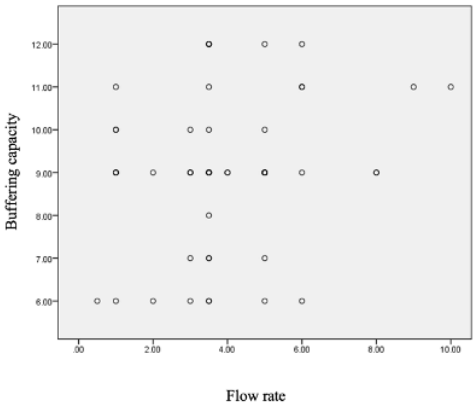

Figure 6.b Correlation between flow rate and buffering capacity in caries free group

Discussion

ECC is a major public health problem in all over the world (Tsai et al., 2006)[17]. It is multifactorial disease, appearing as a result of interaction of multiple factors in the oral medium, such as the existence of a receptive host organism, cariogenic microorganisms and suitable substrate [18]. The nutrition, oral hygiene or consumption of fluoride are variable factors that have more or less effect in each case. Although inappropriate pattern of feeding, oral hygiene care and Strep mutans infection are disease causing but they are not sufficient factors to initiate ECC. Endogenous factors, such as saliva characteristics may be an answer to this question why some children develop ECC while others do not. Saliva is a complex mixture of fluids that surrounds oral tissues and originates from major and minor salivary glands and non-glandular sources such as cell fluid, oral microorganisms and dead cells (Spielmann and Wong, 2011)[19]. Ranganath, Shet and Rajesh (2012)[20] showed that the relationship between the composition of saliva and the cariogenic activity and its beginning and progression.

The present study was designed to compare the salivary characteristics in ECC children and caries free children and to draw the relationship between the salivary characteristics within these two groups. One hundred and twenty subjects with ECC (60) children and caries free (60) children were evaluated for the salivary characteristics consisting of resting salivary pH, buffering capacity and stimulated salivary flow rate. The age range of the study subjects was delimited in order to exclude those over 71 months of age. The mean age of the study group was 5.98 years and mean age of the control group was 5.93. Therefore, the study and control groups did not differ significantly in age. ECC was detected in 84.13% (737) of total examined subjects (876). Caries free subjects were detected in 15.87% (139) of total examined subjects. In ECC group, mean dmft was 6.85 and mean dmfs was 15.97 respectively.

The results of this study included the collection and analysis of resting salivary pH, salivary buffering capacity, and stimulated salivary flow rate data for both the ECC and caries-free groups. In this study, salivary pH values were found to be lower in caries free group. As a result, there were no significant difference between ECC and caries free group. The results obtained are in accordance with the studies performed by Prabhakar et al. (2009) [21] and Preethi, Reshma and Anand (2010)[11]. The salivary pH was only slightly reduced in caries free children

compared with ECC children. Tulunoglu, Dermirtas and Tulunoglu (2006)[22] showed no correlation between pH values and caries activity regardless of the age and gender. In addition, Zhou, Bai and Qin (2007)[23] showed that salivary pH of ECC group was statistically higher than that of caries free group. By contrast, the mean values of salivary pH were similar in caries free and rampant caries children (Thaweboon et al., 2008)[13]. Similarly, Swerdlove (1942)[24] and Malekipour, Messripour and Shirani (2008)[25] reported no relationship between the incidence of dental caries and resting salivary pH.

Likewise, there was no significant difference in buffering capacity between ECC and caries free group. However, mean buffering capacity values were found to be higher in caries free group than ECC group. Karshan, Rosebury, and Waugh (1939)[26] also reported that the mean buffering capacity values were higher in the caries-free group. The results obtained are consistent with the studies conducted by Prabhakar, Dodawad, and Raju (2009)[21], and Preethi, Reshma, and Anand (2010)[11]. However, the findings in their studies were not statistically significant. Another study by Zhou, Bai and Qin (2007)[23] showed that salivary buffering capacity from ECC children was statistically higher than that in caries free children. Malekipour, Messripour and Shirani (2008)[25] showed similar results, although the difference was not statistically significant. There is a reasonable evidence to state that salivary buffering capacity protects the tooth from dental caries (Leone and Oppenheim, 2001)[27]. On the other hand, Twetman et al., (1992)[28] reported that salivary buffering capacity was not affected by presence or absence of caries, as a result of comparison between before and after treatment. Salivary buffering capacity prevents reduction in pH by neutralizing acid in oral cavity after sugar intake. In the present study, we observed that 75% subjects in ECC group had low buffering capacity of saliva. This finding is in correlation with previous results of Johansson et al. (1992)[29] and Holbrook, de Soet and de Graaff (1993)[30]. Interestingly, we found that 71% of the subjects in caries free group had decreased salivary buffering capacity. The reasons for this may be due to extrinsic factors such as dietary and oral hygiene habit, as well as intrinsic factor such as bicarbonate content.

Under resting conditions without the exogenous stimulation that is linked with feeding, there is a slow flow of saliva which keeps the mouth moist and lubricates the mucous membrane. This unstimulated saliva is essential for health and well-being of oral cavity and also bestows a strong protective effect to the oral cavity, against dental caries. In general, the higher the flow rate, the faster the clearance and the higher the buffer capacity and thus lesser microbial attacks. The results of our study showed that mean stimulated salivary flow rate was decreased in ECC children in comparison to caries free children. The obtained data in this study indicated no significant difference in salivary flow rate between two groups of ECC and caries free subjects. Parallel results were seen in the studies conducted by Browne et al and Scully where they showed that there was no correlation between salivary secretion rate and caries activity Mandel (1987)[31]. Dental caries is probably the most common consequence of hyposalivation. In contrast to the above, the studies conducted by Birkhed, Heintze, and Russell et al reported that there was no correlation between salivary secretion rate and caries activity (Mandel, 1987)[31]. Lumikari and Loimaranta (2000)[32] also found no correlation between salivary secretion and decay. In contrast, Leone and Oppenheim (2001)[27] showed that diseases such as Sjogren's syndrome as well as taking certain drugs can lead to

hyposalivation, and lower salivary flow rate to the pathological levels dramatically elevates risk of caries. Thaweboon et al., (2008)[13] revealed that mean values of salivary flow rate were similar in caries free and rampant caries children. The salivary flow rate did not influence the presence of rampant caries. Significantly lower salivary flow rate in caries free group may be associated with a number of predisposing factors such as lack of raw material (water), lack of stimulus to the salivary gland or could be a problem with salivary gland itself.

Regarding relation between flow rate and salivary pH in each group, there was no association between resting salivary pH and flow rate in ECC group (r=0.041) and caries free group (r=-0.041). While some studies have found that chronically low salivary flow rate (<0.8-1ml/min stimulated whole saliva) is a strong indicator of an increased risk of caries by Tukia and Tenovuo (1993)[33], Kirstila et al., (1998)[7] but others are not able to demonstrate a relationship or predictive value for individuals with normal salivary flow rate by Dodds et al., (1997)[34] and O'Sullivan and Curzon (2000)[35]. However, Vehkalahti, Nikula-Sarakorpi and Paunio (1996)[36] reported a correlation between low levels of salivary pH and buffering capacity and caries. Furthermore, Raitio, Pienihakkinen and Scheinin (1996)[37] concluded that salivary factors are poor indicators of caries risk and caries experience.

Additionally, there was no correlation between flow rate and buffering capacity in each group. The value of r 0.174 indicated that there was no association between flow rate and buffering capacity in ECC group. The value of r =0.225 indicated that there was no association between flow rate and buffering capacity in caries free group. Although both the salivary flow rate and buffering capacity are related to dental caries, neither of them when used singly showed a sufficient correlation to caries activity of an individual. When these parameters were used in combinations with several other indications of increased risk for caries (Streptococcus mutans, Lactobacilli, diet, drugs, medical disorders, etc.).

Axelsson (2000)[38] identified useful tools for diagnosing potential caries activity and predicting an individual's risk for dental caries. By contrast, the present study found only a weak correlation between buffering capacity and salivary pH in both groups. The value of r 0.258 indicated that there was association between buffering capacity and salivary pH in ECC group. The value of r=0.275 indicated that there was association between buffering capacity and salivary pH in caries free group. The study showed that pH and buffering capacity had a weak correlation with caries activity. Therefore, salivary pH can be influenced by buffering capacity of saliva in each group. Increased buffering capacity of saliva may increase salivary pH in each group. Hence it can be speculated that other factors like micro flora, diet and retention of food might have dominated the buffering capacity to initiate caries, which is multifactorial disease by Mandel (1987)[31].

In the present study, salivary values of caries free group are higher than ECC group. Therefore, it could be suggested that salivary characteristics may provide a caries protective effect. Moreover, caries-free children in this study were more likely to engage in daily tooth brushing with fluoridated toothpaste compared to children with ECC. Nevertheless, no significant differences were observed in the salivary characteristics between the two groups. It is also important to consider variations related to natural developmental processes when using salivary parameters for caries risk prediction in children. This study indicates that assessing salivary pH, buffering capacity, and salivary flow rate

alone is insufficient for reliably predicting ECC risk. A variety of other factors including anatomical, behavioral, dietary, genetic, social, cultural, socioeconomic, and therapeutic influences can significantly impact caries activity, either positively or negatively. Therefore, future research should focus on exploring the functional properties of whole saliva and the roles of its individual components, with appropriate consideration of age-related variations, to develop more accurate models for caries risk assessment.

Conclusion

This study found that salivary characteristics were generally higher in the caries-free group compared to the ECC group. Interestingly, salivary pH values were slightly higher in the ECC group; however, no significant correlation was observed between pH levels and caries activity. Although buffering capacity values appeared lower in the caries-free group, the difference between groups was not statistically significant. Similarly, while the salivary flow rate was higher in the caries-free group, no significant difference was found between the two groups, and no correlation was established between caries activity and flow rate. Regarding the relationship between flow rate and salivary pH, no association was observed in either group. Additionally, no correlation was found between flow rate and buffering capacity in either group. In contrast, a weak correlation was noted between buffering capacity and salivary pH in both groups. These findings suggest that the assessment of salivary pH, buffering capacity, and flow rate alone may not provide a reliable basis for ECC risk prediction. Further comprehensive studies with larger sample sizes and more detailed clinical and laboratory evaluations are needed to clarify the role of salivary physicochemical properties such as flow rate and buffering capacity in relation to dental caries, age, and gender.

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