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Familial and dietary risk factors in Early Childhood Caries

ABSTRACT

Aim *To evaluate the causes of Early Childhood Caries.*
Methods *Study Design: A statistical comparison of two groups of patients, aged between 3 and 6, and their parents, in the 3-year period 2013-2015 was performed. Two groups of patients were selected: 40 children with early childhood caries (ECC group) and 40 children with no decay (controls). Parents were asked to fill out a questionnaire on food habits, oral hygiene habits, fluoride prophylaxis and family history of caries. A dental visit of children and parents was performed (collection of dmft and DMFT index). The saliva features of the two groups of children (concentration of Streptococcus mutans, pH of the oral cavity and buffer capability of stimulated saliva) were examined by means of salivary tests. The distribution of the population was analysed and parametric and non-parametric tests for continuous and non-continuous variables, were used when appropriate. The statistical significance was set at p > 0.005.*

Results and Statistics *The average age, gender and BMI index of children of the two groups was similar. The difference between the two groups is statistically significant for pH (p=0.000) and buffer capability (p=0.001). The DMFT index in the group of mothers of ECC children is higher compared to the mothers of controls (p=0.004). The comparison among the means, for the parameters connected to the consumption of fruit juice, tea, soft drinks, candies, use of pacifier dipped in sugar or honey and the length (in months) of consumption of candies show statistically significant differences (p>0.05). The pH is higher in those children (24) who never consumed fruit juice, tea, soft drinks before the information received (p<0.05).*
Conclusions *Children developing Early Childhood Caries have a diet characterised by high free sugars intake. Diet and, in particular, the consumption of drinks containing free sugars is the most important factor in determining the onset of ECC, being able to affect the oral environment and, in particular, saliva. There is a relationship between maternal and child's oral health, with a DMFT higher in mothers of ECC subjects than in controls' mothers.*

Keywords *Diet; Early childhood caries; Familial risk factors.*

Introduction

In 1978, the American Academy of Pediatric Dentistry and the American Academy of Pediatrics described "Baby Bottle Syndrome" or "Nursing Bottle Syndrome" as a medical entity characterised by a severe form of caries linked to baby bottle feeding. Avoiding bottle feeding after the first birthday was recommended as the limit that should have been applied in order to prevent caries onset [American Academy of Pediatrics, 1978].

Over the next decades, the American Academy of Pediatric Dentistry introduced the definition of "Early Childhood Caries" (ECC) in order to stress the multifactorial aetiology of this disease. It consists in the presence of one or more decayed, missing, or filled teeth in any primary tooth in a child under 6 years of age.

"In children younger than three years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (S-ECC). From ages three through five, one or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth or a decayed, missing, or filled score of greater than or equal to four (age 3), greater than or equal to five (age 4), or greater than or equal to six (age 5) surfaces also constitutes S-ECC" [American Academy of Pediatric Dentistry, 2015/2016].

This disease has a widespread diffusion. The national

research programme "Healthy People 2010", carried out in the United States during the decade 2000-2010[Healthy People, 2010], showed a transition from 18% (1988-1994) to 24% (1999-2004) of children affected by ECC, with a 33% increase. More recent data related to the two-year period 2011-2012 suggest a general decrease of its incidence in American children between 2 and 5 years of age. However the prevalence of this disease is still extremely high in specific children subgroups [Dye et al., 2015a]. High incidence of this disease is well documented in Europe [Davies et al., 2001] and Italy [Nobile et al., 2014] too. The OMS Collaboration Centre for Epidemiology and Community Dentistry (Milan, Italy) conducted a research in 2004-2005 showing 21.6% decay prevalence in four-year old children in Italy [Campus et al., 2009].

The consequences of the disease on a child's health and life quality are numerous and severe [Low et al., 1999]: increased risk of malocclusion and development of new decays, also in the mixed dentition [Al-Shalan et al., 1997]; pain and dental emergencies uprising [Edelstein et al., 2006]; possible modifications in child's development and growth [Ayhan et al., 1996]; risk of bacteremia [Cassamassimo et al., 2009]; difficulties in learning, with a decreased scholastic performance [Blumenshine et al., 2008].

Treatment of children affected by ECC has a great impact on the health system costs [Goszkowski R, 2013; Agency for Healthcare Research and Quality, 2015]. Every year 1/3 of the treatments made in general anaesthesia, in children younger than 6 years of age, is performed for the treatment of this disease (Canadian Institute for Health Information, 2010-2012).

There are several risk factors [Ministero della Salute, 2013] linked to this disease: *Streptococcus mutans* can colonise child's oral cavity easily and precociously, as a result of particular features of this bacterium and the presence of predisposing factors linked to the host's oral cavity [Law et al., 2007]; structural features of the enamel and dentin in the primary dentition can predispose to decay [Giuliana et al., 2006]; poor oral hygiene, with resulting deposit of plaque, affect colonisation by *Streptococcus mutans* [Alaluusua and Malmivirta, 1994]; poor dietary habits [Chankaka et al., 2012] and low socioeconomic status [Selwitz et al., 2007] can contribute to the onset of decay.

Focusing on the factors at the basis of Early Childhood Caries has the primary purpose of acting as soon as possible with the introduction of preventive measures.

Patients and methods

In order to examine the causes of ECC, two groups of pre-school patients were examined. The centres involved in the research are: the Department of Paediatric Dentistry, Istituto Stomatologico Italiano (Milan, Italy), and the Dentistry Clinic at the Santa Chiara Hospital (Pisa, Italy).

In the 3-year period 2013-2015, two groups of patients were selected: 40 children with early childhood caries (ECC group) and 40 children with no decay (controls), aged between 3 and 6 years.

Study Protocol "Early Childhood Caries (ECC)"	
Last name	Name
dmft	
Date of birth	
Age	
Gender	
FAMILY HISTORY: Mother	
Weight (kg)	
Height (m)	
BMI	
Education level	
Smoker: no	no longer since
yes	n° cigarettes/day
dental disease	
DMFT	
Breastfeeding: no/yes/duration	
FAMILY HISTORY: Father	
Weight (kg)	
Height(m)	
BMI	
Education level	
Smoker: no	no longer since
yes	n° cigarettes/day
dental disease	
DMFT	
Breastfeeding: no/yes/duration	

FIG. 1A First part of the questionnaire: subjects' data.

Information about the development of decays and the presence of pain were collected during the dental visit and from the parents. Parents were asked to fill out a questionnaire on food habits, oral hygiene habits, fluoride prophylaxis and family history of caries. Parents have been visited too, in order to collect information about their oral health (DMFT index) and habits (Fig. 1).

The saliva features of the two groups of children (concentration of *Streptococcus mutans*, pH of the oral cavity and buffer capability of stimulated saliva) were examined by means of salivary tests (Fig. 2).

ECC children's treatment was performed in general anaesthesia at the Istituto Stomatologico Italiano, Milan. One month after the treatment, ECC children were checked and the questionnaires were filled out. A planned meeting with the nutritionist paediatrician has been performed to assess the nutritional state by means of BMI (Body Mass Index), lifestyle and dietary habits of the child. Dietary advices were given in case of unhealthy behaviours (Fig. 3).

At the Dental Clinic of Santa Chiara Hospital, the ECC children visited underwent a series of controls and

Child history				
Breastfeeding	No	yes		
	duration		exclusive	
	start formula			
Did you receive information on dental hygiene?	no	yes		
Did the child underwent prophylaxis with fluoride?	no	yes	age	dosage
How many times do you think dental brushing should be performed?	1	2	3	>3 times a day
Do you use fluoride toothpaste?	no	yes		
How many times a day does the child brush or has his/her teeth brushed?	1	2	3	>3 times a day
Does the child use dental floss?	no	yes	Frequency of use	
Does/did the child use a pacifier?	no	yes	up to	
Did/Do you dip the pacifier in sugar or honey?	no	yes		
Does/did the child drink fruit juice with a baby bottle?	no	yes		
Does or did the child have the habit of drinking or sucking anything but water before sleeping?	no	yes		
Does the child follow a specific diet?	If yes, state specific diet and reasons			
Fruit juices				
in the last month	Never	yes	ml/day	ml/week
In the past	Never	yes	ml/day	ml/week
from the age of:				
Canned tea				
in the last month	Never	yes	ml/day	ml/week
In the past	Never	yes	ml/day	ml/week
from the age of:				
Soft drinks				
in the last month	Never	yes	ml/day	ml/week
In the past	Never	yes	ml/day	ml/week
from the age of:				
Candies				
in the last month	Never	yes	ml/day	ml/week
In the past	Never	yes	ml/day	ml/week
from the age of:				
others				

FIG. 1B Second part of the questionnaire: lifestyle of children.

pH salivary test

This test assesses the saliva acidity and therefore the risk of enamel demineralisation.
< 6.8: pH acid saliva
= > 6.8: pH normal saliva
Buffer capability test

It is mainly constituted by bicarbonate and phosphate system. These systems buffer acid pH and bring it back over the risk threshold value for enamel demineralisation. If buffer capability is low, decay risk increases.
< 10: low buffer capability
= > 10: normal or high buffer capability
Streptococcus mutans test

This test detects the concentration of Streptococco mutans in host saliva. A concentration over the threshold value (5 x 105 CFU/mL) expresses an increased decay risk.
Positive: concentration> 5 x 105 CFU/mL
Negative : concentration< 5 x 105 CFU/mL

FIG 2 Salivary tests used.

outpatient treatments.

The questionnaires were collected during the first visit.

The distribution of the population was analysed and parametric and non-parametric tests for continuous and non-continuous variables, were used when appropriate. The statistical significance was set at $p > 0.005$.

Results

During the 3-year period 2013-2015, 80 children were

Eating habits usual consumption during these meals	
Breakfast	
	Semi-skimmed milk
	Whole milk
	Glass (100 ml)
	Cup (200 ml)
	Bowl (250 ml)
	Whole yogurt
	Fruit yogurt
	Drinkable yogurt
	Cereals
	Chocolate cereals
	Dry cookies
	Chocolate pastries
	Bread and jam
	Snack foods
	Croissant
	Toast
	Fruit
	Fruit juice
	Nothing
Mid-morning snack	
	Yogurt
	Drinkable yogurt
	Cracker
	Fruit
	Fruit juice
	Snack foods
	Sandwich with ham or sausage or cheese
	Chocolate
	Tea (can)
	Soft drinks
	Nothing
Afternoon snack	
	Yogurt
	Drinkable yogurt
	Cracker
	Fruit
	Fruit juice
	Snack foods
	Sandwich with ham or sausage or cheese
	Chocolate
	Tea (can)
	Soft drinks
	Nothing
After dinner/evening	
	Sweet
	Chocolate
	Soft drinks
	Nothing

FIG 3A Questionnaire on dietary habits in children.

Frequency of consumption of the following foods at lunch or dinner			
Foods	Yes	No	N° of times a week
Pasta			
Rice			
Red meat			
White meat			
Fish			
Legumes as single dish			
Legumes as side dish			
Milk/yogurt			
Parmesan cheese			
Fresh cheese			
Aged cheese			
Eggs			
Ham			
Other cured meats			
Vegetables			
Fruit			
Potatoes			
Bread			
Crackers			
Sweets			
Chocolate			
Fruit juice			
Packaged tea			
Soft drinks			

FIG 3B Questionnaire on dietary habits in children.

examined by means of a questionnaire and salivary tests. All the parents agreed to the collection of data about their children and 79 parents out of 80 in the control group and 77 parents out of 80 in the ECC group agreed to a dental visit for DMFT assessment.

Table 1 shows the distribution of the 80 patients and of their parents in relation to gender, age, BMI (Body Mass Index, kg/m^2), dmft index (DMFT for adults), nutritional status and salivary tests, in the two groups, ECC and controls and. The average age, gender and BMI index of children of the two groups was similar: Age: 62.2 (± 13.6) months (controls), 62.3 (±11.4) months (ECC). Gender: 21 females and 19 males (controls), 19 females and 21 males (ECC). BMI: 16.7 (±2.5) in the control group, 16.9 (±2.3) in the ECC group. The dmft index is statistically higher in ECC group (6.3 ± 3), in comparison with control group (p = 0.000). Dietary status is similar in the two groups. All controls underwent the salivary tests, while in the ECC group only 36 out of 40 subjects were submitted to the salivary test. The difference between the two groups is statistically significant for pH (p=0.000) and buffer capability (p=0.001). The DMFT index in the group of mothers of ECC children is higher compared to the mothers of controls (p=0.004). Fathers' DMFT and BMI indices of the two groups of parents do not show

Variable	Controls (n=40)	ECC (n=40)	P-value
Gender F/M	21/19	19/21	
Age (months)	62.2 ± 13.6	62.3 ± 11.4	ns
BMI	16.7 ± 2.5	16.9 ± 2.3	ns
Dmft	0	6.3 ± 3.0	0.000
Nutritional state			
Normal-weight	28	25	
Overweight	11	12	
Underweight	0	1	
Not weightable children (due to low collaboration)	1	2	
Salivary tests	40/40	36/40	
pH	7.3 ± 0.3	6.9 ± 0.4	0.000
Buffer capability	10.2 ± 1.3	9.0 ± 1.7	0.001
S. mutans test	0.7 ± 0.4	0.8 ± 0.3	ns
Parents			
DMFT Mothers	8.8 ± 4.7	12.1 ± 4.7	0.004
DMFT Fathers	9.5 ± 4.6	11.8 ± 5.3	ns
BMI	25.2 ±	24.7 ±	ns

TABLE 1 PDistribution of the 80 subjects and parents related to gender, child's age, dmft index (DMFT for adults), BMI and salivary tests (average values ± standard deviation).

statistically significant differences.

Table 2 shows the distribution, for controls and ECC subjects, of the amount and length of consumption of fruit juice, canned tea, soft drinks, candies, and use of pacifier dipped in sugar or honey. The comparison among the means, for the parameters connected to the consumption of fruit juice, tea, soft drinks, candies, use of pacifier dipped in sugar or honey shows statistically significant differences ($p > 0.05$). Moreover, also the length (in months) of consumption of candies shows a statistically significant difference between the two groups.

Table 2 shows also the distribution of breastfeeding and its duration for both groups. There are not significant differences between the groups.

Table 3 shows the distribution of patients based on the consumption or not of free sugars drinks, before the instruction given to families in order to control the dietary habits.

The pH is higher in those children (n. 24) who never consumed fruit juice, tea, soft drinks before the information received ($p<0.05$).

No statistically significant differences between the two groups were found regarding general data on parents (smoking, dental diseases, educational level); number of couples of parents who received advices on dental hygiene; number of patients that used fluoride toothpaste; average consumption of fluoride and average duration of fluoride prophylaxis.

In a linear regression model of variables such as saliva pH and buffer capability, consumption of free sugars drinks and candies did not show to be independent predictor of dmft (r2 0.25 p=0.32).

Variable	Controls (n=40)	ECC (n=40)	P-value
Amount of fruit juice (ml/die)	49.5 ±85.7	181 ±180	0.001
Amount of tea (ml/die)	6.3 ±32.9	82.2 ±101.7	0.00
Amount of soft drink (ml/die)	8.4 ±34.2	41 ±79.6	0.019
Amount of candies (number/die)	17; 2 ±1.6	30; 3 ±3.7	ns
Total intake of free sugar drinks (ml)	66.9 ±114.1	289.8 ±254.7	0.000
Length of consumption of fruit juice (months)	29.7	34.4	ns
Starting age of fruit juice consumption (months)	26.5	24.1	ns
Length of consumption of tea (months)	40.3	34.3	ns
Starting age of consumption of tea (months)	19.2	22.2	ns
Length of consumption of soft drink (months)	29.0	28.1	ns
Starting age of consumption of soft drinks (months)	18.8	34.8	ns
Length of consumption of candies (months)	19.8	27.8	0.037
Starting age of consume of candies (months)	38.4	33.5	ns
Use of pacifier with sugar/honey (N)	1	9	0.007
Breastfeeding (N/total)	36/40	32/40	ns
Duration of breastfeeding (months)	9.2	8.1	ns

TABLE 2 Consumption of free sugars (average ± standard deviation).

Variable	Children who consumed free sugars drinks before dietary advices (n=56)	Children who did not consume free sugars drinks before dietary advices (n=24)	P-value
pH	7.03 ± 0.4	7.25 ± 0.4	0.027
Buffer capability	9.46 ± 1.7	10.0 ± 1.3	ns

TABLE 3 Distribution of 80 patients related to pH and buffer capability, on the basis of consumption of free sugars drinks, before receiving dietary advices (average values ± standard deviation).

Discussion

The two examined groups are homogeneous on the

basis of gender, age, BMI, nutritional status, oral hygiene habits and systemic and topical fluoride prophylaxis.

The first statistically significant result is the very high quantity of drinks and food containing free sugars (fruit juices, canned tea, soft drinks, candies, pacifier dipped in sugar or honey) consumed by ECC children for long periods. The most important data is the average daily consumption of fruit juice (181 ml/die).

The main difference between the two groups is the quantity of free sugars consumed. The definition of decay as a multifactorial disease does not have to deflect the attention from its main aetiological factor: the quantity of daily free sugars consumed [Bankel et al., 2011]. In particular, sucrose is needed as substratum in the production of extracellular polysaccharides, which in turn facilitate bacterial adhesion to the dental surface and increase the porosity of plaque in close contact with the tooth, with a consequent production of acid on the enamel surface [Ministero della Salute, 2013]. This condition represents an aggravating factor in decay development in primary teeth, owing to the thinner and uniform enamel of primary teeth. Moreover, dentin is less hard in primary teeth than in permanent ones, since dentin tubules have a non-homogenous distribution [Giuliana et al., 2006].

The salivary features in the two groups show lower values of pH ($p = 0.000$) and buffer capability of stimulated saliva ($p = 0.001$) in ECC subjects than controls. A diet rich in free sugars leads to a reduction of pH in the oral cavity, due to the acid produced by bacterial metabolism. The consequent mechanism of demineralisation (transfer of minerals from the hard tissues of tooth to the oral environment), is counterbalanced by the buffering system of saliva, in 30 minutes approximately; minerals lost during demineralisation are reinstated through an opposite remineralisation process. The more frequently free sugars are consumed, the more frequently the pH drops below the threshold value, with consequent difficulty in buffering the generated acidity [Ministero della Salute, 2013].

The excessive consumption of added free sugars has systemic consequences too.

In children, more than 125 ml/day can cause osmotic diarrhoea.

The role of sugars contained in drinks on the onset of overweight and obesity in children is highly discussed. Consumption of drinks containing added sugars, in particular fructose, continues to increase and can play an important role in the epidemic of obesity, metabolic syndrome and fatty liver [Costacurta et al., 2014]. There is evidence that a reduction in the consumption of soft drinks is linked to a decrease of overweight and an improvement of sugar metabolism.

A systematic review [Te Morenga et al., 2012] which investigates the effects of free sugars intake on adiposity development enables to conclude that the decrease or increase of free sugars in diet influences weight in children and adults. The current evidence supports the recommendation to decrease free sugars intake to below 10% of the total energy intake.

This is strongly recommended by the guidelines of the World Health Organization [2015], promoted in 2015. Moreover, the WHO recommends to further limit free sugars intake to less than 5% of the total energy intake. This entails to pay attention to those packaged foods generally not considered as source of sugars: for example, 1 teaspoon of ketchup contains approximately 4 gr of free sugars; 1 can (equivalent to 10 teaspoons) of soft drinks contains 40 gr of sugars.

In the present study, the duration of consumption of candies is higher in ECC subjects than controls. As for the consumption of the other free sugars, the duration of consumption is similar in the two groups. This further underlines the fact that the quantity of free sugars, consumed daily for long periods, represents the main factor influencing the onset of decay.

The number of breastfed children and the length of breastfeeding are higher in controls, however these data do not achieve statistical significance. This minimal difference could be considered to be in line with the indications of the World Health Organization [World Health Organization], which recommends exclusive breastfeeding during the first 6 months of a child's life, and consider breastfeeding as the best diet for infants.

Also significant is the warning coming from a recent study conducted in Japan [Kato et al., 2015]: "infants who had been breast fed for at least 6 or 7 months, both exclusively and partially, were at elevated risk of dental caries at the age of 30 months compared with those who had been exclusively formula fed". Authors state the need of further extensive studies on this issue.

The mothers of ECC children generally have, on average, a higher DMFT (Decayed Missing Filled Teeth) than the mothers of controls ($p=0.004$). This shows a higher tendency to decay in those children whose mothers suffer from dental problems and have poor oral hygiene[Boggess and Edelstein, 2006; Caufield et al., 1993]. The transmission of bacteria from mother to child occurs directly through the saliva. The factors influencing this type of transmission are the level of bacteria contained in maternal saliva, the frequency of contact between maternal and child's saliva, age, the child's salivary flow and diet.

Numerous studies have hypothesised a relationship between maternal periodontal disease and lower birth weight, preeclampsia and preterm birth [Caufield et al., 1993].

Conclusion

The sample examined, even if not representative of the Italian paediatric population, raises many issues.

Children developing ECC have a diet characterised by high free sugars intake [Bahuguna R et al., 2013]. Diet

and, in particular, the consumption of drinks containing free sugars is the most important factor in determining the onset of ECC, being able to affect the oral environment and, in particular, saliva.

The saliva pH is directly influenced by diet, especially a high intake of added free sugars. Also the buffer capability is statistically lower in ECC subjects than controls. A further study hypothesis could be the relationship between the exhaustion of buffer capability in stimulated saliva, produced by major salivary glands, due to excessive acid attacks.

Another result of this study is the confirmed relationship between maternal and child's oral health, with a DMFT higher in mothers of ECC subjects than in controls' mothers. This proves the importance of prevention in mothers, to raise awareness on the need for taking care of their mouth in view of benefits for the child.

ECC is an extremely current and widespread issue, and affects a high number of children in western countries, right where general better living conditions should warrant a better health. In 2014, ECC was the topic of a conference entirely dedicated to this issue [Garcia et al., 2015], with the aim of reviewing its epidemiology, aetiology, prevention and management. The conference stressed the need of further studies on preventive measures and management of ECC.

Given the same oral environmental features, home oral hygiene and fluoride prophylaxis measures, the most important factors in the onset of ECC, are acquired and linked to the diet.

An increasingly close cooperation between paediatricians and paediatric dentists is needed. The multidisciplinary relationship between different professionals that provide child's health raises the chances of an educative intervention focused on prevention, from early childhood.

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