Gatt, G., Schembri, M., Vassallo, P., Gainza-Cirauqui, M. L., Zahra, E. V., and Attard, N. (2017). *Xjenza Online*, 5:98–109.

Xjenza Online - Journal of the Malta Chamber of Scientists
www.xjenza.org
DOI: 10.7423/XJENZA.2017.2.02

Research Article

Erosive Tooth Wear in Children and Adolescents

Gabriella Gatt*[1], Miriam Schembri[2], Paula Vassallo[2], Maria Luisa Gainza-Cirauqui[3], Ethel Vento Zahra[2] and Nikolai Attard[2]

[1]*Department of Child Dental Health and Orthodontics, Faculty of Dental Surgery, University of Malta, Mater Dei Hospital, Msida, Malta*

[2]*Department of Oral Rehabilitation and Community Care, Faculty of Dental Surgery, University of Malta, Mater Dei Hospital, Msida, Malta*

[3]*Department of Dental Surgery, Faculty of Dental Surgery, University of Malta, Mater Dei Hospital, Msida, Malta*

Abstract. To determine the local prevalence of erosive tooth wear in the child population and to identify the degree to which local demographic and socio-economic factors influence prevalence, a multi-stage cluster sample of three, five, eight, twelve and fifteen-year old Maltese school children were identified. The children were clinically examined under standardised conditions and provided a questionnaire to be filled directly (twelve and fifteen-year-olds) or by the parents/legal guardians (three, five and eight-year-olds). A total of 2508 children were examined. Of these, 232 three-year-old, 338 five-year-old children, 337 eight-year-old children, 642 twelve-year-old children and 560 fifteen-year-old children returned a questionnaire and were analysed. The prevalence of erosive tooth wear was $> 70\%$ in all age cohorts. Erosion experience also increased in both extent and severity with age in each dentition. Significant higher incidences were observed in eight-year old males, eight-year old overweight children, eight and fifteen-year-olds attending public schools, locality (Gozo > Malta), history of vomiting in fifteen-year olds, and children from lower socioeconomic parental status in five, eight and fifteen-year-olds.

The prevalence of erosive tooth wear is high in school aged Maltese children. This easily preventable tooth condition deserves targeted public health programmes to improve the oral health of future generations.

Keywords: Dental erosion, children, prevalence, demographic factors

1 Introduction

Wear of the dentition is a normal physiological process that may be observed in both the primary and permanent dentition. When the rate of wear, however, exceeds the reparative efforts of the tooth complex, wear becomes pathological. Wear due to repetitive contact with exogenous items such as incorrect toothbrush use, an excessively fibrous diet or the habitual holding of items by the teeth is termed abrasion. Attrition produces opposing highly polished wear facets arising due to the tooth to tooth contact. Erosive wear, on the other hand, is the chemical dissolution of tooth tissue due to successive episodes of exposure to intrinsically or extrinsically derived acids over a long enough span of time (Ganss, 2014). Erosive dental wear presents as a flattening of convex tooth surfaces, rounded cusps, occlusal concavities and in severe cases the loss of all tooth morphology (Fig. 1). Al-Dlaigan, Shaw and Smith (2001) describe how in younger populations, erosive tooth wear is the main contributory factor towards all tooth wear observed, rather than attrition or abrasion. Unlike dental caries, erosive tooth wear is not related to the longstanding presence of bacteria and the consumption of sugar.

Despite the concept that wear is a chronic condition requiring a long period of time between the exposure to the risk factors and subsequent clinical signs, erosive dental wear is, however, being increasingly diagnosed globally in the primary dentition in pre-school aged children (Al-Malik, Holt & Bedi, 2002; Harding, Whelton, O'Mullane & Cronin, 2003; Huang, Leishman, Newman & Seow, 2015; Mantonanaki, Koletsi-Kounari, Mamai-Homata & Papaioannou, 2013; Murakami et al., 2016) affecting dentitions that therefore have been present in

**Correspondence to*: Gabriella Gatt (gabriella.gatt@um.edu.mt)

Figure 1: Erosive tooth wear in a nine-year-old child.

the oral environment for a mere two to four years.

Erosive tooth surface loss has been largely associated with the high consumption of acidic soft drinks, fruit juices and carbonated drinks (Holbrook, Arnadottir & Kay, 2003). Erosive tooth wear is also linked to socioeconomic status, as exemplified by parental education, notably the mother's education is significantly influential (Kumar, Kroon & Lalloo, 2014). Various studies though, present conflicting results concerning gender differences due to regional- and age-related differences (El Aidi, Bronkhorst & Truin, 2008; Milosevic, Young & Lennon, 1994; Nayak, Ashokkumar, Ankola & Hebbal, 2010). Moreover erosive lesions in primary molars are strongly and positively correlated to gastroesophageal reflux disease (GERD) (Campisi et al., 2008), eating disorders, such as anorexia and bulimia nervosa (Clearfield & Roth, 1985; Jarvinen, Rytomaa & Meurman, 1992), and asthma (Al-Dlaigan, Shaw & Smith, 2002).

Results of published erosion prevalence studies range from 7% in three-year-old children (Huang et al., 2015), to 77% in two to four- year-old children (Taji & Seow, 2010). The percentage of teeth with exposed dentine in fourteen-year-olds rose from 30% in 1994 (Milosevic et al., 1994) to 53% in 2004 (Bardsley, Taylor & Milosevic, 2004). The UK National Child Dental Health Surveys showed an increase of 3% of exposed dentine excluding incisal edges in fifteen-year olds in 2003 as compared to 1993 (Chadwick, White, Morris, Evans & Pitts, 2006). In a study carried out on twelve-year-old Indian school children, a prevalence of erosion was found to be 34.12% (Sinha, Abdullah, Saha & Verma, 2016).

Diagnosing erosive wear in the child is important for various reasons. The presence of erosive lesions in the primary dentition, particularly those with exposed dentine (Harding, Whelton, Shirodaria, O'Mullane & Cronin, 2010), carry with them a risk for the person presenting later with lesions in the permanent dentition (Ganss, Klimek & Giese, 2001). Uncontrolled wear of the dentition leads to exposure of underlying dentine with associated sensitivity, whilst severe wear may also result in the deterioration of the dentition. The erosive process also produces a decrease in micro hardness of dental tissues rendering the tooth surfaces more susceptible to alternative wear processes: abrasion and attrition. This ongoing process can lead to irreversible, invasive and costly treatment (Ganss, 2014) and deterioration in the quality of life (Li & Bernabe, 2016).

The aim of the study was to determine the local prevalence of erosive tooth wear in the child population and to identify the degree to which local demographic and socio-economic factors influence prevalence. This will help policy makers plan appropriate interventions and target resources accordingly.

2 Materials and Methods

2.1 Sample

Sample size: A review of the pertinent literature was carried out to analyse prevalence data figures for dental erosion in children. Due to the wide ranging published prevalence figures ranging from 0.6% (Moimaz, Araujo, Chiba, Garbin & Saliba, 2013) to 100% (Jaeggi & Lussi, 2014) an expected frequency of 50% was set. The statistical package Epi-Info^{TM} (CDC, 2007) set sample sizes. This was in accordance with total national population numbers (NSO, 2014), a degree of accuracy of $p = 0.05$ and a confidence level of 95%. Deliberate over-sampling was carried out in anticipation of study cohort attrition due to factors including non-compliance from pre-cooperative participants, absentees, refusals of consent and failure of returned questionnaires. Data from final sample numbers of 232 three-year-old children, 338 five-year-old children, 337 eight-year-old children, 642 twelve-year-old children and 560 fifteen-year-old children was analysed.

Sampling Procedure: The cross-sectional study was designed using a multi-stage cluster sampling technique. Representations of both localities of residence and school type were considered in order to incorporate all socio-economic bands. A planned sampling ratio was embodied into the school selection process reflecting the proportional distribution of children found within the three schooling systems. Within each individual school, the classes to screen were then cluster-selected in a simple random method.

Inclusion Criteria: Children who were included in the study were those resident on the Islands all their lives and who turned three, five, eight, twelve or fifteen years old in that calendar year.

Exclusion Criteria: Children who did not return a signed consent form were also excluded.

2.2 Ethical Approval

A detailed research protocol was prepared to abide to all the requirements as stated in the World Medical Association Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects (General Assembly of the World Medical Association, 2014). The protocol was submitted for consideration, guidance and approval to the Faculty of Dental Surgery Research Ethics Committee and subsequently to the University of Malta Research Ethics Committee (UREC MD 31/2013). The study was also registered with the Local Data Protection Officer.

Approval was also sought from the relevant authorities in the three school streams. (State schools, Church schools and Independent schools). Additional signed parental consent was also sought after having distributed information sheets to all parents/legal guardians at least three weeks prior to the school visit.

2.3 Calibration of examiners

Training and calibration of examiners and scribes in the use of the Basic Erosive Wear Examination Index (BEWE) were carried out by an internationally renowned researcher in the field. The examiners included four dental surgeons; the scribes were two dental hygienists. Training and calibration programs organised by the Faculty of Dental Surgery included seminars, discussions, simulation laboratory sessions and clinical sessions over several days. Further calibration sessions were carried out involving duplication of examination of clinical cases in order to assess intra- and inter-examiner reliability.

An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among examiners. Additional intra-examiner reliability was determined by carrying out repeat examinations of random participants during the study.

2.4 Clinical Examination

Examinations were held on school premises during school hours. A portable dental unit (Jiangsu Dynamic DU892, Zhengzhou Smile Dental Equipment Co., Ltd. Henan, China) provided compressed air. A Daray X200LED mobile examination light provided a standardised source of light delivering 8,000 lux at 1 m and 32,000 lux at 0.5 m (Daray Lighting Ltd., Leighton Buzzard, Luton, UK). Sterile wrapped packs containing a front surface reflecting mirror and a ball-ended WHO CPITN-E probe was available for each participant. Data were recorded by trained scribes onto number coded data input sheets. Examiners wore individual protection equipment while the children were examined in a supine position. Repeat examinations of two randomly selected children were carried out at each school visit to assess intra-examiner reproducibility. Participants were screened for erosive tooth wear, dental caries and dental fluorosis. They were also charted for the presence of plaque, calculus, dental traumatic injuries and soft tissue lesions. Each child needing treatment was given a referral note. Repeated observations at two separate visits were carried out for the three-year-old cohort and the five-year-old cohort two and three years apart respectively.

2.5 Indices

Erosive tooth wear – The Basic Erosive Wear Examination (BEWE) Index was used to score an index value per participant. The BEWE Index examines all surfaces of all teeth (excluding third molars) and records the highest score (0–3) for each sextant (55–54, 53–63, 64–65, 75–74, 73–83, 84–85). The sum of all six scores (max 18) is the participant's cumulative score. Cut-off values of the cumulative scores then guide the clinical management for that level of erosive tooth wear (Bartlett, Ganss & Lussi, 2008). For the purpose of this study, participants were assigned to an erosion experience category according to their individual cumulative score. Table 1 depicts the distribution of categories.

Table 1: BEWE Erosion Experience Categories according to cumulative score

Cumulative Score of all Sextants	Experience Level	BEWE Erosion Experience Categories for this study
0–2	None	BEWE 1
3–8	Low	BEWE 2
9–13	Medium	BEWE 3
14–18	High	

The Erosion Experience Level Groups 'Medium' and 'High' (cumulative scores 9–18) were grouped together as they form a homogeneous group in terms of the clinical management recommended by the BEWE Index (Bartlett et al., 2008).

2.6 Height and Weight Measurements – Body Mass Index (BMI)

Anthropometric measurements were recorded in a consistent and systematic manner by examiners and scribes using a portable stadiometer (SECA 214 Portable Stadiometer) and portable digital scales (SECA 875 flat scales). Children were asked to remove their school shoes and were measured wearing their uniforms. Participants were instructed to hold the Frankfort plane parallel to the ground whilst measuring their height. The calculated BMI values were then divided into four cat-

egories (Thinness, Normal, Overweight and Obesity) according to the International Obesity Task Force (IOTF) cut-off values (Cole & Lobstein, 2012). Cut-off points at the mid-year value (3.5 years and 5.5 years, 8.5 years, 12.5 years and 15.5 years) were utilised. This is the recommended procedure when carrying out epidemiological studies including age groups of one-year width (Cole & Lobstein, 2012).

2.7 Questionnaire

A piloted and sequentially refined questionnaire in both English and Maltese was set-up and was distributed to parents/legal guardians of all three, five and eight-year-old children screened. The twelve and fifteen-year-old age cohorts were given a self-administered questionnaire to complete.

The questionnaire was designed to enquire about sociodemographic factors, parental/self-perceptions of oral health, oral health habits, dietary habits and general health factors. Sociodemographic variables included gender, age, locality and duration of residence, parental educational level (divided into 4 levels: Primary School level, Secondary School level, Post-Secondary School level and Tertiary level), and parental job type (4 subdivisions: Professional, Clerical/Business, Manual labourer and Unemployed). A question regarding the self/parents' level of satisfaction with dental appearance asked participants to list whether they were 'satisfied', 'not satisfied' or 'don't know'. Participants were asked whether they perceived their own or their child's oral health to be 'good', 'average', 'poor' or 'don't know'. The frequency of visits to the dentist in the past 12 months was also questioned and divided into the following categories: 'Never at all', 'Never in the last year', 'Once', 'Twice', 'Three times' and 'Don't remember'. Six questions from the 13 item Early Childhood Oral Health Impact Scale (ECOHIS) (Pahel, Rozier & Slade, 2007) instrument were also asked. These included questioning about reports of pain, difficulty eating, sensitivity to hot and cold foods, avoidance of smiling, missed days of school and parental days of work. General health-related questions enquired about the use of medications, asthma and its treatment, hospitalisation, gastro-oesophageal reflux disease, history and duration of vomiting and symptoms of dry mouth. The distributed questionnaires were number coded per participant to match the data input forms.

2.8 Data Analysis

The primary outcome of this study was the prevalence of erosive tooth wear in the relative age cohorts. The secondary outcomes were the effect of independent variables upon the BEWE Erosion Experience Category scores. The independent variables included aspects of socio-demographic status and were analysed as categorical variables. Descriptive statistics, tests for normality of data, frequencies and cross tabulations were performed. The Pearson Chi-squared test was used to analyse the differences in proportions in the categories of the various socio-demographic factors presenting in the three BEWE erosion experience categories. Similarly, the Pearson Chi-squared test was also used to explore the relationship between the categories of Parental perception of oral health and further categorical independent variables. When a cell presented with a value ≤ 5 the Fischer's Exact Probability Test was employed instead. The Kruskal-Wallis H Test allowed comparison of the mean ranks scored when carrying out a 'between groups' analysis of BEWE scores, Parental Perception of oral health and parental level of education.

Statistical significance for all tests was set at $p < 0.05$. Statistical tests were carried out using SPSS 20.0 software (IBM Company, Chicago, IL, USA).

3 Results

Kappa values for intra- and inter-examiner reproducibility for the BEWE Index were 0.86 and 0.79 respectively.

3.1 Sample Descriptors

Table 2 depicts the relevant characteristics of the three and five, eight, twelve and fifteen–year-old child samples that participated.

3.2 Prevalence of Erosive Wear according to Age Cohort

Fig. 2 shows how signs of erosive wear on at least one tooth surface (BEWE cumulative score > 0) increased both with increasing age in each dentition type (primary, mixed and permanent dentitions) and also with time between baseline and follow-up examinations, in the three and five-year-old cohorts two to three years apart.

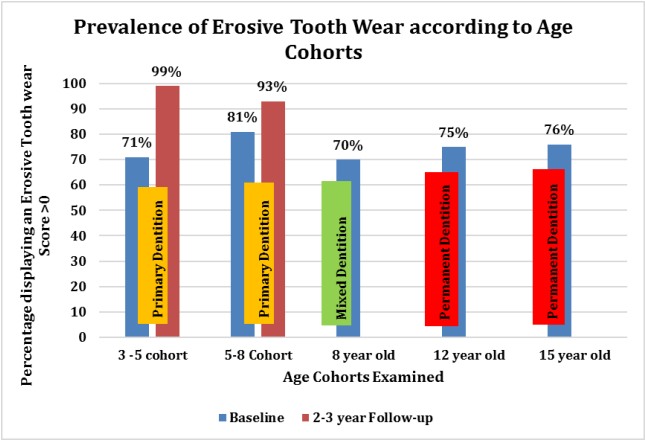

Figure 2: Prevalence of erosive tooth wear according to age cohorts.

Table 2: Sample characteristics.

AGE THREE. TOTAL POPULATION – 4026

52% males, 48% females

SCHOOL TYPE	TARGET	REMAINING AFTER DROPOUTS*	MATCHED WITH QUESTIONNAIRE	QUESTIONNAIRE RESPONSE RATE
INDEPENDENT	80	70	43	61%
CHURCH	40	53	38	72%
STATE	280	213	151	71%
TOTAL	400	336	**232**	

AGE FIVE. TOTAL POPULATION – 3788

54% males, 46% females

SCHOOL TYPE	TARGET	REMAINING AFTER DROPOUTS*	MATCHED WITH QUESTIONNAIRE	QUESTIONNAIRE RESPONSE RATE
INDEPENDENT	60	61	36	59%
CHURCH	120	128	118	92%
STATE	240	251	184	73%
TOTAL	420	441	**338**	

AGE EIGHT. TOTAL POPULATION – 4,393

51% males, 49% females

SCHOOL TYPE	TARGET	REMAINING AFTER DROPOUTS*	MATCHED WITH QUESTIONNAIRE	QUESTIONNAIRE RESPONSE RATE
INDEPENDENT	40	55	40	72.7%
CHURCH	120	164	87	53%
STATE	240	276	210	76%
TOTAL	400	495	**337**	

AGE TWELVE. TOTAL POPULATION – 4255

54% males, 46% females

SCHOOL TYPE	TARGET	REMAINING AFTER DROPOUTS*	MATCHED WITH QUESTIONNAIRE	QUESTIONNAIRE RESPONSE RATE
INDEPENDENT	40	38	38	100%
CHURCH	180	273	273	100%
STATE	280	331	331	100%
TOTAL	500	642	**642**	

AGE FIFTEEN. TOTAL POPULATION – 5,031

53% males, 47% females

SCHOOL TYPE	TARGET	REMAINING AFTER DROPOUTS*	MATCHED WITH QUESTIONNAIRE	QUESTIONNAIRE RESPONSE RATE
INDEPENDENT	40	6	6	100%
CHURCH	180	173	172	99%
STATE	360	416	382	92%
TOTAL	580	594	**560**	

DROPOUTS*: Absent or uncooperative participants

3.3 BEWE Erosion Experience, Severity and Distribution according to sextants

Erosion experience also increased in both extent and severity with age in each dentition – primary and permanent. Participants with a BEWE Erosion Experience Category 3 (medium–high) increased from 8% to 13% from age three to five respectively in the primary dentition. While in the Mixed dentition stage 17% of 8-year-old children scored a BEWE 3 category. When into the permanent dentition, 1.5% of twelve year olds scored a BEWE 3 Erosion Experience Category moving up to 5.7% by age fifteen. In all age cohorts, the upper anterior sextant (53–63) (13–23) was the sextant most affected by erosive tooth wear. However, Fig. 3 depicts how erosive wear has a near whole mouth affect with BEWE scores increasing mostly in the upper labial sextant and the lower buccal sextants. The lower labial sextant remained generally unaffected.

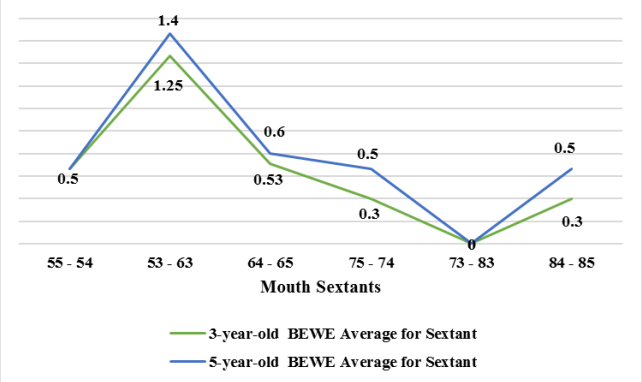

Figure 3: Trends in average BEWE scores per mouth sextant in 3- and 5-year-old children.

3.4 BEWE Erosion Experience and Gender, School Type and Locality of Residence

In the 8-year old group, there was a statistically significant difference between genders; the incidence of erosion being higher in males compared to females (Unpaired t-test: $p = 0.0147$). In all the other cohorts, there was no statistical significant difference between BEWE Erosion Experience Category distribution between males and females.

The type of school attended by the subjects was found to be statistically significant for both 8 and 15-year-old age groups in relation to the incidence of erosion observed, the latter being highest for students attending public schools and lowest reported in students attending independent schools (Fisher's Exact test: $p = 0.0001$). BEWE Erosion Experience Categories within the three different schooling types frequented showed no statistically significant differences in the three, five and twelve-year-old age cohorts (1-way ANOVA F test, $p = 0.071$), ($p = 0.371$) and ($p = 0.305$) respectively.

Statistical tests revealed no significant differences in BEWE Erosion Experience Category between the various districts within the mainland. When, however, all the districts within the island of Malta were compared collectively to the sister island, statistically significant differences were observed. Twenty percent of Gozitan three-year-old child fell into BEWE Erosion Experience Category 3. This was found to be a statistically significant difference to the 7% of Maltese children falling into BEWE Erosion Experience Category 3 ($\chi^2(2, N = 256) = 6.03$, $p = 0.04$). Fig. 4 illustrates how the trend reverses in the five year-old Gozitan cohort who exhibited a significantly lower percentage of children (5.6%,) in BEWE Erosion Experience Category 3 compared to those in Malta (15%,) ($\chi^2(2, N = 337) = 9.829$, $p = 0.007$).

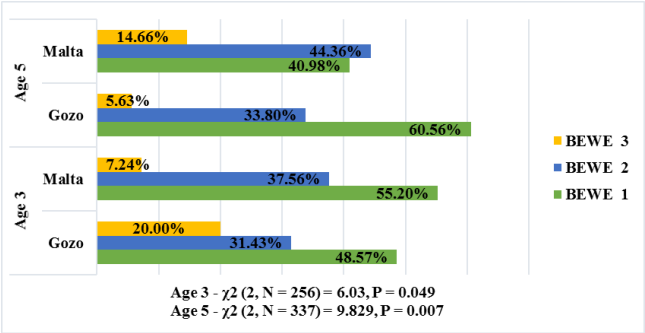

Figure 4: BEWE distribution according to district in 3 and 5-year-old children.

3.5 BEWE Erosion Experience Category and General Health Conditions

Fourteen percent of the preschool aged cohort, 15% of the eight-year-old cohort, 10% of the twelve-year-old adolescents and 8% of the fifteen-year-old teenagers in this study were reported to be asthmatic. In three, five and twelve-year-old children, all factors relating to current ($p = 0.67$), ($p = 0.574$), ($p = 0.585$) or a past history ($p = 0.155$), ($p = 0.224$), ($p = 0.730$) of asthma, and the use of inhalers and any other medications, were found to be unrelated to erosion experience ($p > 0.05$). Additionally, all factors related to hospitalisation ($p = 0.783$), ($p = 0.606$), ($p = 0.260$) vomiting ($p = 0.528$), ($p = 0.164$), ($p = 0.880$) and any symptoms related to gastroesophageal reflux disorder (GERD) did not reach significance in these three age cohorts. These included regurgitation, dry mouth, thirst, heartburn and reports of a bad taste upon awakening ($p > 0.05$). The only medical condition that was statistically related to the incidence of erosion was a history of vomiting in the 15-year old subjects (Fisher's Exact test: $p = 0.01$).

3.6 BEWE Erosion Experience Category and BMI

BMI figures indicated a shift whereby there is a reduced number of children in the Thinness weight range and increased numbers in the Normal, Overweight and Obesity weight ranges in the younger three-year old cohort when compared to the five-year-old group. Statistical tests did not result in significant relationships between BMI category allocation and BEWE Erosion Experience Category allocation for these age cohorts ($p > 0.05$). In both the three and five-year-old age groups a trend was observed whereby a higher representation of children in the overweight/obese group was present in the BEWE Erosion Experience Category 1 (53% ($N = 50$) and 47% ($N = 54$)). In the eight-year-old cohort, however, both males and females in the overweight range were at a higher risk of tooth erosion compared to children identified in the other predefined categories since they represent the lowest percentage of participants in the BEWE Erosion Experience Category 1 (Chi-square test: $p = 0.003$).

3.7 BEWE Erosion Experience Category and Socioeconomic Indicators

In the five (Fig. 5) and fifteen-year-old cohorts alone, children of parents with a tertiary level of education had the lowest representation within the BEWE Erosion Experience Category 3 (10%). Results reached statistical significance ($\chi^2(6, N = 319) = 16.836$, $p = 0.012$), (Fischer's Exact test at $p = 0.035$) respectively. There is a gradual increase in the percentage of subjects at no risk of tooth erosion as the highest level of the mothers' education attained progress from primary school level education to a post-graduate level. A statistically significant relationship between the level of tooth erosion and the occupation of the main breadwinner was observed for the 8-year-old cohort (Fig. 6).

The frequency of visits to the dentist was seen to be unrelated to the parental level of education in the three and five-year-old cohorts ($\chi^2(15, N = 234) = 17.879$, $p = 0.269$).

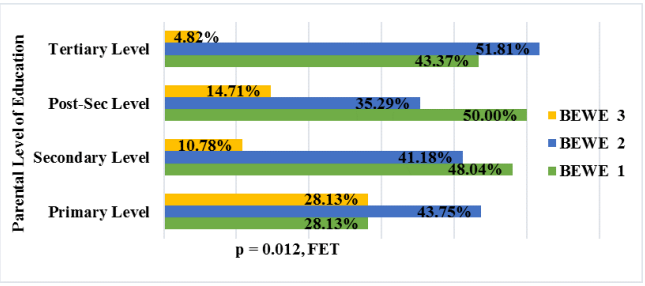

Figure 5: BEWE distribution in 5-year-old children according to the parental level of education.

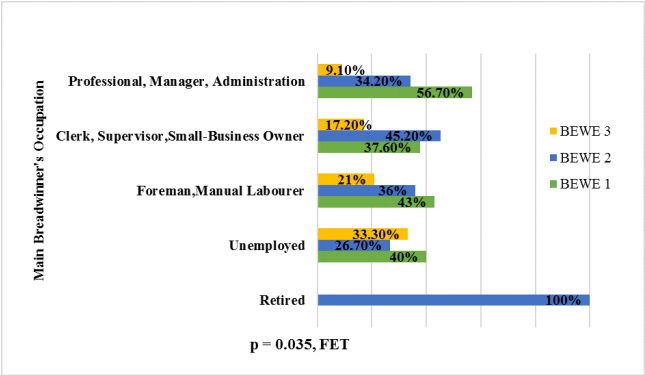

Figure 6: BEWE distribution in 8-year-old children according to occupation of family's main breadwinner.

3.8 Parental Perception of the Oral Health status of their child in relation to BEWE Erosion Experience Category and Parental Level of Education

The higher the level of education of the parents of three and five-year-old children, the more positive were the comments, irrespective of BEWE Erosion Experience Category. A Kruskal-Wallis H test revealed a statistically significant difference in parental perception of the oral health of their children across the different parental levels of education $\chi^2(3, N = 310) = 17.43$, $p = 0.001$. The group with a tertiary level of education recorded a more positive oral health status score for their children ($Md = 2$) as compared to the other groups ($Md = 3, 5$). The parental perception of oral health was seen to be statistically related to appearance, experience of pain and the presence of dental decay but not to erosive wear experience (Table 3).

Eight, twelve and fifteen-year-old participants were asked to describe their own state of health of their teeth. Of note, the highest percentage of respondents in the three age groups perceive their oral health as 'Good' followed by respondents deeming their personal oral health as 'Very good' or 'Average'. Very few respondents classify their oral health as poor or very poor. In eight and fifteen-year-old age groups, no significant correlation was found between the subjects' perception of dental health and the incidence of tooth erosion, possibly indicating that patients are suffering from tooth erosion might be unaware of, or do not appreciate the problem. In the twelve-year-old age group, however, BEWE scores were significantly different ($p = 0.010$) according to the perception of the status of health of their own teeth.

On the other hand, the relation between the self-reported perceptions of dental appearance and the incidence of tooth erosion was significant in the 8-year-old (FET, $p = 0.002$), 12-year-old (ANOVA F test,

Table 3: Parental perception of the child's level of oral health in relation to erosion experience, pain, dental caries and appearance.

	AGE THREE	**AGE FIVE**
Parental perception of oral health in relation to BEWE score	$\chi^2(6, n = 243) = 4.6$, $\mathbf{p = 0.0564}$	$\chi^2(6, n = 334) = 3.371$, $\mathbf{p = 0.739}$
Parental perception of oral health in relation to reporting of pain	$\chi^2(12, n = 243) = 27.58$, $\mathbf{p = 0.027}$	$\chi^2(12, n = 336) = 64.228$, $\mathbf{p < 0.001}$
Parental perception of oral health in relation to presence of caries	$\chi^2(9, n = 245) = 44.313$, $\mathbf{p < 0.001}$	$\chi^2(9, n = 336) = 56.655$, $\mathbf{p < 0.001}$
Parental perception of oral health in relation to appearance	$\chi^2(9, n = 212) = 51.171$, $\mathbf{p < 0.001}$	$\chi^2(4, n = 304) = 21.4$, $\mathbf{p < 0.001}$

$p = 0.022$) and 15-year-old (FET, $p = 0.025$) groups. This is an indication that tooth erosion might have some psychological effects on the affected subjects.

4 Discussion

This cross-sectional study is the first of its kind to assess the prevalence of erosive tooth wear in three and five-year-old pre-school aged children, in eight-year-old children and in twelve and fifteen-year-old adolescents in the Maltese islands. A parent administered questionnaire was distributed to the parents of the three, five and eight-year-old participants while the twelve and fifteen-year-old cohorts completed a self-administered questionnaire. The questionnaire data were used to study the possible influence of socio-demographic factors upon oral health.

Although the final sample size was reduced due to exclusion criteria and non-response of the questionnaire, together with a potential bias from those parents/guardians who were interested in health issues, the study still presents a representative sample of the population studied. Interpretation of the results of this study, therefore, takes into account all these factors associated with the use of questionnaires and the need for parental consent when collecting data.

In this study the prevalence of erosive tooth wear (BEWE Cumulative Score ≥ 1) was recorded at 71% ($n = 238$) in the three-year-old cohort, at 81% ($n = 356$) in the five-year-old cohort, 70% ($n = 320$) in the eight-year-old cohort, 75% ($n = 477$) in the twelve-year-old cohort and 76.3% ($n = 441$) in the fifteen-year-old cohort. Age-specific significant socio-demographic factors that influenced erosion scores were gender, the location of residence, school type, BMI, a history of vomiting and parental level of education.

Comparison of prevalence results with those from other studies is difficult due to the use of different erosion indices. However, results obtained by this study for the preschool aged cohorts are most similar to those reported by Taji and Seow (2010) at 77% in two to four-year old children (Modified Smith and Knight clinical index) and Mantonanaki et al. (2013) at 78.8% in five-year-old children where the BEWE Index was utilised. That by Tschammler, Muller-Pflanz, Attin, Muller and Wiegand (2016) is the one other study that utilised the BEWE index together with the O'Sullivan Index on both three and five-year-old children reporting agreement between the two indices. This latter study reported the prevalence of 14.2% in three-year-old children and 58.8% in five-year-old children. Similarly, a national study carried out in Iceland in 2010 on fifteen-year-olds concluded that 30% of examined subjects suffered tooth erosion to some degree (Arnadottir et al., 2010) whilst in a study carried out in the Netherlands in 2009, 44.2% of fifteen-year old students suffered erosion (El Aidi, Bronkhorst, Huysmans & Truin, 2010). This study also follows the pattern seen in results of a study carried out by Kreulen et al. (2010) where higher percentages of wear into dentine of deciduous teeth were observed when compared to permanent teeth. The difference is partially attributable to the examination of the deciduous teeth for the younger age groups which would have been exposed to acidic threats for a longer period of time compared to the permanent dentition, including the buccal segments, examined in the twelve and fifteen-year olds subjects, which, besides having a higher micro hardness level, would have only just recently erupted into the mouth.

Similar to the findings by Moimaz et al. (2013), Tong, Rudolf, Muyombwe, Duggal and Balmer (2014) who reported no gender difference in erosion prevalence in four to six-year-old children, this study also found no statistically significant association between gender and prevalence of erosion in the preschool aged cohorts. These age groups did, however, show an 8% increment in the count of males in the BEWE Erosion Experience Categories 2

and 3 proceeding from the three to the five-year-old cohort while a 5% difference was observed in the female groups. Consistent with findings from epidemiological surveys carried out in other countries (Arnadottir et al., 2010; Milosevic et al., 1994), gender was found to be a predisposing factor for erosion for the eight and fifteen-year-old age groups. As suggested by Bardsley et al. (2004) the lower incidence of tooth wear in females could be attributed to better oral hygiene and lower consumption of carbonated beverages or alcoholic drinks when compared to their male counterparts. These attributes were also observed in this study.

The socioeconomic standing of a child is most often measured in terms of the type of school attended, locality of residence and the main caregiver/breadwinner's occupation and/or level of education. As stated previously, studies assessing the association between socioeconomic standing and erosion experience have given widely opposing results (Dugmore & Rock, 2004; Harding et al., 2003, 2010; Kumar et al., 2014; O'Brien, 1994; Vazquez-Nava et al., 2010). This study found an association between the parental occupation and erosion experience. Erosion experience was however found to be related to the parental level of education in most age groups but to a statistically significant level in the 5 and 15-year-old age cohorts alone. In accordance with some studies (Kumar et al., 2014) but contrary to other studies (O'Brien, 1994), this study showed that a higher level of parental education and occupation appeared to protect against erosive wear in select age cohorts.

The schooling system on the island may only be loosely associated with demographic properties and socioeconomic status. A stratified cluster-sampling technique was however employed when selecting the participating schools in order to ensure proportionate representations for each functioning school type. Results reached statistical significance in the eight and fifteen-year-old cohorts alone. This highlights that oral health educational programs are to target all children irrespective of socioeconomic standing.

This study also sought to investigate any association between general health parameters and chronic illnesses that may be related to erosive tooth wear, including asthma and reflux disorders. The Body Mass Index (BMI), which is a reflection of lifestyle/dietary habits and used to assess risk for chronic diseases, was calculated for each child. Attempts have been made to study the link between BMI and oral health findings. While D'Mello, Chia, Hamilton, Thomson and Drummon (2011) found no association between obesity and dental caries in children less than 8 years of age, a systematic review carried out found a significant association (Hayden et al., 2013). Though there is an established link between obesity and poor periodontal health in adults (Saito, Shimazaki, Koga, Tsuzuki & Ohshima, 2001), there is little published data referring to the child patient, and further studies are needed to confirm the hypothesis of this link (Katz & Bimstein, 2011). Dental erosion, obesity and dietary habits are an interconnected triad sharing common risk factors. Similar to other studies which found an association between BMI and erosion risk in 7 to 15 year old children (Tong et al., 2014), this study found a significant relationship between these two factors in just the eight-year-old cohort. These results are indicative that the components contributing towards overweight/obesity are not constantly in common with those predisposing to erosive tooth wear. Use of the common risk factor approach in preventive management for these two conditions would, therefore, have to be applied cautiously.

The associations between erosive tooth wear, asthma and gastroesophageal reflux disorder (GERD) (O'Sullivan, Curzon, Roberts, Milla & Stringer, 1998; Tootla, Toumba & Duggal, 2004) have been researched extensively. Dental erosion has been described as an extra oesophageal manifestation of GERD while GERD itself is extremely common in child patients and is often overlooked (Yuksel, Yilmaz, Kirmaz, Aydogdu & Kasirga, 2006). Asthma has been directly linked to erosive dental wear due to the low pH values of relief bronchodilators, and the low oral pH conditions they cause. A study measured the inherent pH and titratable acidity of commercially available paediatric asthma inhalers and reported the inherent pH of dry powder inhalers to have a mean value of 5.06. When used regularly, beta-2 adrenoceptor agonists reduce the salivary flow rate and therefore indirectly, cause erosion (Thomas, Parolia, Kundabala & Vikram, 2010). The resulting oral dehydration may also lead to an increase in consumption of acid drinks further contributing to a higher risk for erosive tooth wear. This study found no statistically significant association between dental erosion and both GERD and asthma possibly due to the young age of the participants and therefore an insufficient exposure time for a visible effect to be observed clinically.

Similar to the findings observed in our study, vomiting over a period of time has also been identified as being crucial in approximately one quarter of all cases of dental erosion (Jarvinen et al., 1992). While medical assistance should be sought to treat disorders with vomiting, regurgitation or reflux of gastric contents over a prolonged period, it is important to minimize the tooth wear whilst the condition is being treated. A neutralisation procedure is useful for the prevention of erosion, given it is employed immediately following the acid challenge (Imfeld, 1996b). Acid neutralization may be attempted by holding some milk in the mouth for a short

time after vomiting (Imfeld, 1996a). Consuming milk or cheese (Gedalia et al., 1991) was reported to reharden pre-softened enamel specimens.

The educational level of the parent was significantly linked to the parent's perception of oral health in the five-year-old age group ($p = 0.035$) and was not associated with the number of dental visits. Aesthetics and erosive wear were significantly linked in the eight, twelve and fifteen-year-old participants; the perception of the level of dental health and erosive wear was not.

5 Conclusion

This study has provided evidence that erosive tooth wear is significantly present in the young child and adolescent irrespective of most socio-demographic factors. These findings reinforce the need for more public health programs which target the whole spectrum of society including childcare personnel, social workers and general healthcare providers in an effort to increase levels of oral health literacy and thereby help young children access better dietary habits and the dental care they require. Additionally, more preventive interventions are to be targeted at teenagers in order to promote healthier lifestyle choices.

Acknowledgements

The authors thank Joseph Galea, Sandra Milton and Veronica Montebello for their assistance with scribing during the screening procedures. In addition, we also thank Joseph Galea for his help with the input of the data. The project was funded by the University of Malta Research Grants.

References

Al-Dlaigan, Y. H., Shaw, L. & Smith, A. (2001). Dental erosion in a group of British 14-year-old, school children. Part I: Prevalence and influence of differing socioeconomic backgrounds. *Br Dent J*, *190*(3), 145–149.

Al-Dlaigan, Y. H., Shaw, L. & Smith, A. J. (2002). Is there a relationship between asthma and dental erosion? A case control study. *Int J Paediatr Dent*, *12*(3), 189–200.

Al-Malik, M. I., Holt, R. D. & Bedi, R. (2002). Erosion, caries and rampant caries in preschool children in Jeddah, Saudi Arabia. *Community Dent Oral Epidemiol*, *30*(1), 16–23.

Arnadottir, I. B., Holbrook, W. P., Eggertsson, H., Gudmundsdottir, H., Jonsson, S. H., Gudlaugsson, J. O., ... Agustsdottir, H. (2010). Prevalence of dental erosion in children: a national survey. *Community Dent Oral Epidemiol*, *38*(6), 521–526.

Bardsley, P. F., Taylor, S. & Milosevic, A. (2004). Epidemiological studies of tooth wear and dental erosion in 14-year-old children in North West England. Part 1: The relationship with water fluoridation and social deprivation. *Br Dent J*, *197*(7), 413–6, discussion 399.

Bartlett, D., Ganss, C. & Lussi, A. (2008). Basic Erosive Wear Examination (BEWE): a new scoring system for scientific and clinical needs. *Clin Oral Investig*, *12 Suppl 1*, S65–8.

Campisi, G., Lo Russo, L., Di Liberto, C., Di Nicola, F., Butera, D., Vigneri, S., ... Di Fede, O. (2008). Saliva variations in gastro-oesophageal reflux disease. *J Dent*, *36*(4), 268–271.

CDC. (2007). Epi Info^{TM}. Retrieved May 2014, from https://www.cdc.gov/epiinfo/index.html

Chadwick, B. L., White, D. A., Morris, A. J., Evans, D. & Pitts, N. B. (2006). Non-carious tooth conditions in children in the UK, 2003. *Br Dent J*, *200*(7), 379–384.

Clearfield, H. R. & Roth, J. L. A. (1985). *Anorexia, Nausea and vomiting in Blockus gastroenterology.* Philadelphia: Saunders.

Cole, T. J. & Lobstein, T. (2012). Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes*, *7*(4), 284–294.

D'Mello, G., Chia, L., Hamilton, S. D., Thomson, W. M. & Drummon, B. K. (2011). Childhood obesity and dental caries among paediatric dental clinic attenders. *Int J Paediatr Dent*, *21*(3), 217–222.

Dugmore, C. R. & Rock, W. P. (2004). A multifactorial analysis of factors associated with dental erosion. *Br Dent J*, *196*(5), 283–6, discussion 273.

El Aidi, H., Bronkhorst, E. M., Huysmans, M. C. & Truin, G. J. (2010). Dynamics of tooth erosion in adolescents: a 3-year longitudinal study. *J Dent*, *38*(2), 131–137.

El Aidi, H., Bronkhorst, E. M. & Truin, G. J. (2008). A longitudinal study of tooth erosion in adolescents. *J Dent Res*, *87*(8), 731–735.

Ganss, C. (2014). Is erosive tooth wear an oral disease? *Monogr Oral Sci*, *25*, 16–21.

Ganss, C., Klimek, J. & Giese, K. (2001). Dental erosion in children and adolescents–a cross-sectional and longitudinal investigation using study models. *Community Dent Oral Epidemiol*, *29*(4), 264–271.

Gedalia, I., Dakuar, A., Shapira, L., Lewinstein, I., Goultschin, J. & Rahamim, E. (1991). Enamel softening with Coca-Cola and rehardening with milk or saliva. *Am J Dent*, *4*(3), 120–122.

General Assembly of the World Medical Association. (2014). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *J Am Coll Dent*, *81*(3), 14–18.

Harding, M. A., Whelton, H. P., Shirodaria, S. C., O'Mullane, D. M. & Cronin, M. S. (2010). Is tooth wear in the primary dentition predictive of tooth wear in the permanent dentition? Report from a longitudinal study. *Community Dent Heal. 27*(1), 41–45.

Harding, M. A., Whelton, H., O'Mullane, D. M. & Cronin, M. (2003). Dental erosion in 5-year-old Irish school children and associated factors: a pilot study. *Community Dent Heal. 20*(3), 165–170.

Hayden, C., Bowler, J. O., Chambers, S., Freeman, R., Humphris, G., Richards, D. & Cecil, J. E. (2013). Obesity and dental caries in children: a systematic review and meta-analysis. *Community Dent Oral Epidemiol*, *41*(4), 289–308.

Holbrook, W. P., Arnadottir, I. B. & Kay, E. J. (2003). Prevention. Part 3: prevention of tooth wear. *Br Dent J*, *195*(2), 75–81.

Huang, L. L., Leishman, S., Newman, B. & Seow, W. K. (2015). Association of erosion with timing of detection and selected risk factors in primary dentition: a longitudinal study. *Int J Paediatr Dent*, *25*(3), 165–173.

Imfeld, T. (1996a). Dental erosion. Definition, classification and links. *Eur J Oral Sci*, *104*(2 (Pt 2)), 151–155.

Imfeld, T. (1996b). Prevention of progression of dental erosion by professional and individual prophylactic measures. *Eur J Oral Sci*, *104*(2 (Pt 2)), 215–220.

Jaeggi, T. & Lussi, A. (2014). Prevalence, incidence and distribution of erosion. *Monogr Oral Sci*, *25*, 55–73.

Jarvinen, V., Rytomaa, I. & Meurman, J. H. (1992). Location of dental erosion in a referred population. *Caries Res*, *26*(5), 391–396.

Katz, J. & Bimstein, E. (2011). Pediatric obesity and periodontal disease: a systematic review of the literature. *Quintessence Int*, *42*(7), 595–599.

Kreulen, C. M., Van 't Spijker, A., Rodriguez, J. M., Bronkhorst, E. M., Creugers, N. H. & Bartlett, D. W. (2010). Systematic review of the prevalence of tooth wear in children and adolescents. *Caries Res*, *44*(2), 151–159.

Kumar, S., Kroon, J. & Lalloo, R. (2014). A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral health related quality of life. *Heal. Qual Life Outcomes*, *12*(1), 41.

Li, M. H. & Bernabe, E. (2016). Tooth wear and quality of life among adults in the United Kingdom. *J. Dent. 55*, 48–53.

Mantonanaki, M., Koletsi-Kounari, H., Mamai-Homata, E. & Papaioannou, W. (2013). Dental erosion prevalence and associated risk indicators among preschool children in Athens, Greece. *Clin Oral Investig*, *17*(2), 585–593.

Milosevic, A., Young, P. J. & Lennon, M. A. (1994). The prevalence of tooth wear in 14-year-old school children in Liverpool. *Community Dent Heal. 11*(2), 83–86.

Moimaz, S. A., Araujo, P. C., Chiba, F. Y., Garbin, C. A. & Saliba, N. A. (2013). Prevalence of deciduous tooth erosion in childhood. *Int J Dent Hyg*, *11*(3), 226–230.

Murakami, C., Tello, G., Abanto, J., Oliveira, L. B., Bonini, G. C. & Bonecker, M. (2016). Trends in the prevalence of erosive tooth wear in Brazilian preschool children. *Int J Paediatr Dent*, *26*(1), 60–65.

Nayak, S. S., Ashokkumar, B. R., Ankola, A. V. & Hebbal, M. I. (2010). Distribution and severity of erosion among 5-year-old children in a city in India. *J Dent Child*, *77*(3), 152–157.

NSO. (2014). *Demographic Review 2013*. National Statistics Office. Valletta, Malta.

O'Brien, M. (1994). *Children's dental health in the United Kingdom 1993: a survey carried out by the Social Survey Division of OPCS, on behalf of the United Kingdom Health departments, in collaboration with the Dental Schools of the Universities of Birmingham and Newcastle*. London: H.M.S.O., 1994: Office of Population Censuses and Surveys. Social Survey Division; University of Birmingham. Dental School; University of Newcastle upon Tyne. Dental School.

O'Sullivan, E. A., Curzon, M. E., Roberts, G. J., Milla, P. J. & Stringer, M. D. (1998). Gastroesophageal reflux in children and its relationship to erosion of primary and permanent teeth. *Eur J Oral Sci*, *106*(3), 765–769.

Pahel, B. T., Rozier, R. G. & Slade, G. D. (2007). Parental perceptions of children's oral health: the Early Childhood Oral Health Impact Scale (ECOHIS). *Heal. Qual Life Outcomes*, *5*, 6.

Saito, T., Shimazaki, Y., Koga, T., Tsuzuki, M. & Ohshima, A. (2001). Relationship between upper body obesity and periodontitis. *J Dent Res*, *80*(7), 1631–1636.

Sinha, P., Abdullah, S., Saha, S. & Verma, A. (2016). Prevalence of dental erosion in 12-year old school children of Lucknow City. *J. Indian Assoc. Public Heal. Dent. 14*, 409–412.

Taji, S. & Seow, W. K. (2010). A literature review of dental erosion in children. *Aust Dent J*, *55*(4), 358–67, quiz 475.

Thomas, M. S., Parolia, A., Kundabala, M. & Vikram, M. (2010). Asthma and oral health: a review. *Aust Dent J*, *55*(2), 128–133.

Tong, H. J., Rudolf, M. C., Muyombwe, T., Duggal, M. S. & Balmer, R. (2014). An investigation into the dental health of children with obesity: an analysis of dental erosion and caries status. *Eur Arch Paediatr Dent*, *15*(3), 203–210.

Tootla, R., Toumba, K. J. & Duggal, M. S. (2004). An evaluation of the acidogenic potential of asthma inhalers. *Arch Oral Biol*, *49*(4), 275–283.

Tschammler, C., Muller-Pflanz, C., Attin, T., Muller, J. & Wiegand, A. (2016). Prevalence and risk factors of erosive tooth wear in 3-6 year old German kindergarten children-A comparison between 2004/05 and 2014/15. *J Dent*, *52*, 45–49.

Vazquez-Nava, F., Morales Romero, J., Crodova Fernandez, J. A., Saldivar-Gonzales, A. H., Vazauez-Rodriguez, C. F., Barrientos Gomez Mdel, C., ... Vazquez Rodriguez, E. M. (2010). Association between obesity and asthma in preschool Mexican children. *Scientific World Journal*, *10*, 1339–1346.

Yuksel, H., Yilmaz, O., Kirmaz, C., Aydogdu, S. & Kasirga, E. (2006). Frequency of gastroesophageal reflux disease in nonatopic children with asthma-like airway disease. *Respir Med*, *100*(3), 393–398.