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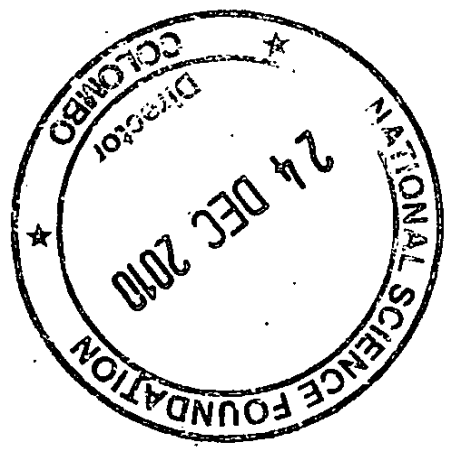
FINAL REPORT OF RESEARCH GRANT NO. RG/2007/ HS/11



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FR 1716.

SECTION 1

INFORMATION REGARDING PROJECT/PROJECT PERSONNEL:

Contract Number – 077-2920897

Title of the Project – Prevalence and risk indicators of tooth wear in 17-year-old school children in Colombo district

Principal Investigator – Dr. NC Ratnayake

Co-Investigators – Prof. SL Herath

Institute(s) where research was being carried out – Government, private and international schools in Colombo district

Date of award – 03/12/2007

Date of completion of Project – 31/03/2009

Total allocation of funds (Rs) - 449,115/= (but received only Rs. 355,810/=)

Total spent - (Rs) 354,095/28

Number of Research Students employed - Nil

Number of Technical Assistants and/or labourers employed and period of service –

Technical assistants – 1 (one) from January 2008 to March 2009

Labourers – 1 (one) From January 2008 to December 2008

SECTION 2

EXECUTIVE SUMMARY OF THE PROJECT:

Background and objectives

Tooth wear has been recognized as an emerging dental problem among adolescents in the developed countries. Many authors attributed this disease trend to the increased consumption of acidic food, mainly carbonated beverages, associated with improving socio-economic standards. However, there is paucity of information on tooth wear among adolescents from developing countries. Therefore, the aim of the present study is to assess the prevalence and associated factors of tooth wear among 17-year-old school children in the Colombo District of Sri Lanka.

Methodology

The study consisted of two components. A cross-sectional school based study was conducted in order to determine prevalence, severity, distribution and risk indicators of and awareness about tooth wear among the adolescents. A total of 1200 17-year-olds were selected from the schools in the Colombo district using a two stage cluster sampling method combined with probability proportional to size (PPS) technique. Subjects were requested to complete a self-administered questionnaire on potential risk indicators and knowledge about tooth wear. Oral examination was carried out to assess tooth wear using Smith and Knight (1984a) Tooth Wear Index. In the second component of the study, seventeen brands of carbonated beverages available in the market were analysed for acidity, calcium and fluoride ion concentrations.

Major findings

Prevalence of tooth wear was 22%. Fourteen-per-cent only had tooth wear lesions confined to the enamel while 9% had tooth wear lesions extending up to the dentine. The mean number of tooth surfaces affected by tooth wear per subject was 3.5 while it was 2.6 and 1.0 for enamel wear and dentine wear, respectively. Tooth wear lesions were symmetrically distributed in the dental arches. Teeth in the upper arch were more affected by enamel wear than teeth in the lower arch while dentine wear was more in the lower arch than in the upper arch.

In the multiple logistic regression analyses, monthly family income exceeding Rs. 30,000 (OR = 2.01, 95% CI = 1.10-3.67, p=0.02), consumption of oranges at least once a week (OR = 1.83, 95% CI = 1.00 -3.33, p=0.048) and consumption of Coca Cola at least once a week (OR = 1.88, 95% CI = 1.06-3.35, p=0.03) emerged as significant predictors of prevalence of tooth wear. Consumption of Fanta at least once a week was significantly associated with the prevalence of enamel wear. Attending a private or international school (OR = 3.12, 95% CI = 1.07-9.11, p=0.04) and consumption of Coca Cola at least once a week (OR = 6.05, 95% CI = 1.92-19.00, p=0.002) emerged as significant predictors of prevalence of dentine wear.

Analysis of beverages revealed that the pH values of locally available brands of carbonated beverages were low when compared with other reported studies. Moreover, the study revealed that the knowledge about tooth wear and dental erosion among these adolescents was poor.

SECTION 3

REPORT IN DETAIL:

Introduction

Tooth wear (tooth surface loss) could occur due to erosion, abrasion or attrition. However, there is growing evidence that dental erosion is the main factor responsible for tooth wear in the younger population (Smith, Bartlett and Robb, 1997; O'Brien, 1994; Shaw and Smith, 1998).

The major cause for dental erosion in children and young adults is believed to be the frequent consumption of acidic food and drinks (Watt, Dykes and Sheiham, 1999; May and Waterhouse, 2003; Harley, 1999). Other causes for erosion are frequent use of medications (Randell *et al*, 2003; Pontefract *et al*, 2001), regurgitation of gastric contents (Oginni, Agbakwuru and Ndububa, 2005) and exposure to acids in certain occupations (Amin and Al-Omoush, 2001; Skogedal *et al*, 1977).

The present study is aimed at determining the burden and potential risk indicators of tooth wear among adolescents in Sri Lanka. Since the study population will be adolescents, it is reasonable to assume that tooth surface loss observed in these children is mainly due to dietary erosion. Therefore, it is important to analyze their diet, particularly the commonly consumed beverages for their acid content. This information would be useful for planning and implementing public health preventive strategies targeted particularly towards adolescents. The study would certainly yield valuable information on different socio-demographic characteristics and risk behaviors in relation to tooth wear/dental erosion.

Objectives

General Objective

To assess the prevalence and associated factors of tooth wear in 17-year-old school children in Colombo District of Sri Lanka.

Specific Objectives

1. To estimate the prevalence and severity of tooth wear in 17-year-old school children in Colombo District
2. To describe the distribution of tooth wear lesions in the dentition of 17-year-old school children in Colombo District.
3. To describe the association between tooth wear and potential risk indicators (dietary, socio-demographic, behavioural ect.) of tooth wear/dental erosion.

4. To chemically analyze random samples of carbonated beverages available in the market to determine their calcium and fluoride ion concentrations and acidity.

5. To assess the awareness about tooth wear/dental erosion among the 17-year-old school children.

Methodology

This study consists of two main components.

Component I

Assessment of prevalence, severity, distribution, risk indicators of tooth wear and awareness about tooth wear among a representative sample of 17-year-old school children in the Colombo district.

Component II

Chemical analysis of random samples of carbonated beverages available in the market to determine their calcium and fluoride ion concentrations and acidity.

Component I

Study Design

A cross-sectional school based descriptive study on tooth wear in 17-year-old school children from the Colombo district.

Study Setting

The study setting was government, private and international schools in the Colombo administrative district of the Western province of Sri Lanka.

Sample size

Since data on prevalence of tooth wear/dental erosion are not available for Sri Lankan children, for the purpose of calculating the sample size, the prevalence of tooth wear/dental erosion in 17-year-olds was considered as 50%. After considering the study objectives and study design, the sample size was determined using the formula by Lwanga and Lemeshow (1991). Thus the minimum sample size was 384.

Since it was decided to use the cluster sampling technique to select the sample, it was necessary to consider the *design effect* (Bennett *et al*, 1991; Abrahamson and Abrahamson, 1999). Considering the fact that there were no calculated figures for design effect in a cluster-sample survey of tooth wear in a similar population and the small cluster size involved in the present study, it was decided to set the value of design effect at 2. Moreover, it was anticipated that there could be a higher percentage of non-respondents compared to that of the pilot study which was 23%. Therefore 30% allowance was made for non-respondents.

$$384 \times 2^{*} = 768$$
$$768 + (768 \times 30\%^{\#}) = 998$$

* design effect
\# non-respondents

Thus the minimum sample size required was 998.

Milosevic, Bardsley and Taylor (2004) highlighted the importance of studying large samples in this type of studies on tooth wear, in order to capture sufficient number of cases for extensive analysis for risk indicators. However, after considering the logistics involved and the time frame available, the sample size was increased only up to 1200.

Sampling technique

A two-stage cluster sampling technique was employed to select the sample.

Index Used

A modified version of Smith & Knight (1984a) index of tooth wear was used in the present study. In modifying the index and defining scores, three previous modifications of the Smith and Knight (1984a) index were considered (Millward, Shaw and Smith, 1994; O' Brien, 1994; Bardsley, Taylor & Milosevic, 2004).

Data Record Sheet

Based on the tooth wear record sheet of Bardsley, Taylor and Milosevic (2004), a data record sheet was developed to record tooth wear according to the modified version of Smith and Knight Tooth Wear Index (1984a).

Questionnaire

A self-administered, pre-tested, validated, semi-structured questionnaire was administered to all subjects prior to the clinical examination. The questionnaires used in two previous studies among adolescents in the United Kingdom were used as a guide in preparing the questionnaire (Bardsley, Taylor and Milosevic, 2004; Milosevic, Lennon and Fear, 1997). The questionnaire was intended to obtain information pertaining to putative risk factors and protective factors of different types of tooth wear.

Examiner training and calibration

All clinical examinations were carried out by the principal investigator. The principal investigator was calibrated with a Consultant in Restorative Dentistry in recording tooth wear using the modified version of Smith & Knight (1984a) index. Calibration exercises were carried out until a satisfactory level of agreement was achieved. Cohen's Kappa statistic was

calculated to assess the agreement. Every 10th student was re-examined to test for the intra-examiner agreement and Cohen's Kappa statistic was calculated.

Component II

Laboratory analysis of beverages

Random samples of seventeen brands of carbonated beverages available in the market were chemically analysed for acidity and concentrations of calcium and fluoride ions. Laboratory analysis was performed in the Division of Biochemistry, Department of Basic Sciences, Faculty of Dental Sciences, University of Peradeniya. Laboratory procedures were carried out under the supervision of the academic staff of the Division of Biochemistry.

Collection of samples of carbonated beverages

Samples sealed in plastic bottles which were not exposed to sunlight and stored in a dry place at room temperature were purchased for analysis. Refrigerated samples were not considered. Samples were collected randomly from different outlets in Colombo, Kegalle and Kandy districts. The minimum volume of a bottle purchased was 350 ml. Three bottles of each brand (one from each district) were purchased. They were from different batches.

Measuring pH of beverages

Hanna pHep® pH meter (Hanna Instruments Inc., Italy) was used to measure the pH of beverages. The instrument was calibrated using a pH 7.01 buffer solution. Measurements were carried out at room temperature. The first reading was taken immediately upon opening the bottle and subsequently four other readings were taken within a period of 10 minutes. The mean of these 5 readings was considered as the pH of the beverage.

Measuring calcium and fluoride ion concentrations

Orion® Benchtop Ion Selective Electrode Meter (Analytical Technology Inc., USA) was used for measuring both calcium and fluoride ion levels. Ionplus® calcium electrode (Orion Research Inc., USA) and the Orion® fluoride/ combination fluoride electrode (Orion Research Inc., USA) were used in the analysis of calcium and fluoride respectively. Five readings were taken from each sample. The mean calcium and fluoride concentrations were determined.

Data analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS©) version 13.

Ethical Considerations

Ethical clearance was obtained from the Ethical Review Committee of the Faculty of Medicine, University of Colombo. Written informed consent was obtained from children and their parents on a specially designed consent form.

Results

Prevalence of tooth wear

Following definitions were used in describing prevalence of tooth wear.

1. Prevalence of enamel wear – proportion of subjects having at least one enamel wear lesion in their mouth, but do not have dentine wear.
2. Prevalence of dentine wear – proportion of subjects having at least one dentine wear lesion in their mouth.
3. Prevalence of tooth wear – Proportion of subjects having at least one tooth wear (either enamel or dentine) lesion in their mouth.

The prevalence of tooth wear is shown in table 1.

Of the total sample, 22% had at least one surface affected by tooth wear. In nearly 14% of the sample tooth wear was confined to the enamel while 8.7%, had lesions extending up to the dentine.

Tooth wear involving the pulp was not found among the children in this population.

Table 1. Prevalence of tooth wear among the sample

Type of wear	Number	%
Enamel wear	154	13.7
Dentine wear	98	8.7
Tooth wear	252	22.4

** total number of children = 1123*

Severity of tooth wear

Table 2. Surfaces affected by tooth wear

	Number of surfaces	Mean surfaces in total sample (n = 1123)	Mean surfaces in those with tooth wear (n = 252)
Only enamel wear	2885	2.57 ± 7.0	11.45 ± 10.7
Dentine wear	1087	0.97 ± 5.4	4.31 ± 10.7
Total tooth wear	3972	3.54 ± 10.5	15.76 ± 17.2

A total of 3972 tooth surfaces were affected by tooth wear in the total sample. The mean number of tooth surfaces affected by tooth wear per student was 3.5 ± 10.5 (Table 2).

There were 2885 surfaces where tooth wear was confined to the enamel (Code 1 of the index) in the total sample (Table 2). The mean number of tooth surfaces affected with only enamel wear was 2.57± 7.0 per student.

Dentine wear (Code 2 and 3 of the index) was seen in 1087 surfaces in the total sample, with a mean of 0.97 ± 5.4 surfaces affected per student.

Table 3 Distribution of students according to the number of tooth surfaces affected by tooth wear

Surfaces with tooth wear	Number of students	% of students (n = 252)	% of total sample (n = 1123)
1 to 2	80	31.7	7.1
3 to 10	66	26.2	5.9
11 to 20	41	16.3	3.7
21 to 30	13	5.2	1.2
31 to 40	11	4.4	1.0
41 to 50	27	10.7	2.4
51 to 60	14	5.5	1.2
Total	252	100.0	22.4

Of those affected by tooth wear, a majority (32%) had only one or two affected surfaces. In nearly 6%, 51-60 surfaces were affected (Table 3).

Distribution of tooth wear

Of the total surfaces in the upper arch of the population 4.2% of surfaces were affected by tooth wear. In the lower arch, of the total surfaces, 4.4% affected by tooth wear.

Table 4. Distribution of tooth surfaces affected with tooth wear in upper and lower arches

	Upper arch		Lower arch		Total	
	n	%	n	%	n	%
Enamel wear	1505	3.2*	1380	3.0**	2885	3.1***
Dentine wear	443	1.0*	644	1.4**	1087	1.2***
Tooth wear	1948	4.2*	2024	4.4**	3972	4.3***

n = Number of affected surfaces.
% = percentage of affected surfaces out of total surfaces at risk
*= Number of surfaces at risk (denominator) = 46,221
**= Number of surfaces at risk (denominator) = 45,282
***= Number of surfaces at risk (denominator) = 91,503

Of the total surfaces in the population, enamel wear and dentine wear was seen in 3.1% and 1.2% of the surfaces, respectively.

Of the total surfaces, tooth wear was seen in 4.3%.

Multiple logistic regression analysis for risk indicators of tooth wear

Independent effects of the risk indicators on the prevalence of tooth wear were investigated using multiple logistic regression models. Three separate models were fitted for

1. Enamel wear
2. Dentine wear
3. Tooth wear

All independent variables which showed a significant association with the dependent variable at a significance level of $p<0.05$ in the bivariate analysis - were entered into multiple logistic regression models. Backward elimination of the independent variables was carried out.

Table 5. Multiple logistic regression model for enamel wear (n = 1123)

Independent variable	Odds ratio	95% Confidence interval	p-value
Nail biting			
Never	1.00		
Occasionally	1.02	0.47-2.21	0.96
Regularly	0.56	0.25-1.26	0.16
Acid taste in mouth			
Never	1.00		
Occasionally / Regularly	0.60	0.34-1.06	0.08
Regular sports activities			
Yes	1.00		
No	0.56	0.31-1.01	0.06
Fanta®			
≤Once a week	**1.00**		
>Once a week	**1.60**	**1.05-2.44**	**0.03**

Dependent variable enamel wear status dichotomized as
0 = no enamel wear ; 1 = enamel wear
$\chi^2 = 20.43$ ($p<0.001$), Pseudo $R^2 = 0.04$

The multiple logistic regression model for enamel wear is shown in Table 5. Of the independent variables, only consumption of Fanta® at least once a week emerged as a significant determinant of enamel wear. Those who consume Fanta® at least once a week were 1.6 times more likely to get enamel wear than those who did not (95% CI = 1.05 – 2.44, $p = 0.03$). The total variance in enamel wear explained by the logistic regression model was only 4% (Pseudo $R^2 = 0.04$).

Table 6. Multiple logistic regression model for dentine wear (n = 1123)

Independent variable	Odds ratio	95% Confidence interval	p-value
Type of School			
Government	**1.00**		
Private / International	**3.12**	**1.07-9.11**	**0.04**
Monthly family income (Rupees)			
≤30,000	1.00		
>30,000	2.58	0.97-6.83	0.06
Coca Cola®			
≤Once a week	**1.00**		
>Once a week	**6.05**	**1.92-19.00**	**0.002**

Dependent variable dentine wear status dichotomized as
0 = no dentine wear ; 1 = dentine wear
$\chi^2 = 32.74$ ($p<0.000$), Pseudo $R^2 = 0.26$

The multiple logistic regression model fitted for dentine wear is shown in Table 6. Of the three independent variables retained in the model, two variables were significantly associated with 'dentine wear'. Consumption of Coca-Cola®at least once a week with an odds ratio of 6.05 (95% CI = 1.92 – 19.00, $p = 0.002$) had the strongest association with dentine wear. Students of private or international schools were three times more likely to have dentine wear than those of government schools. The total variance in dentine wear explained by the logistic regression model was 26% (Pseudo $R^2 = 0.26$)

Table 7. Multiple logistic regression model for tooth wear (n = 1123)

Independent variable	Odds ratio	95% Confidence interval	p-value
Mother's level of education			
GCE A/L or less	1.00		
Degree or diploma	2.73	0.904-8.287	0.08
Monthly family income (Rupees)			
≤30,000	**1.00**		
>30,000	**2.01**	**1.10-3.67**	**0.02**
Oranges			
≤Once a week	**1.00**		
>Once a week	**1.83**	**1.00-3.33**	**0.048**
Coca Cola®			
≤Once a week	**1.00**		
>Once a week	**1.88**	**1.06-3.35**	**0.03**

Dependent variable tooth wear status dichotomized as
0 = no tooth wear ; 1 = tooth wear
$\chi^2 = 24.10$ ($p<0.000$), Pseudo $R^2 = 0.10$

The multiple logistic regression model explaining total tooth wear is shown in Table 7. Of the four independent variables retained in the model, three variables were significantly associated with tooth wear. Monthly family income exceeding Rs. 30,000 with an odds ratio of 2.01 (95% CI = 1.10 – 3.67, $p = 0.02$) had the strongest association with tooth wear. Moreover, consumption of oranges more than once a week (OR = 1.83; 95% CI = 1.00-3.33; $p = 0.048$) and Coca-Cola more than once a week (OR = 1.88; 95% CI = 1.06-3.35; $p = 0.03$) emerged as significant determinants of tooth wear. The total variance in tooth wear explained by the logistic regression model was 10% (Pseudo $R^2 = 0.10$).

Chemical analysis of carbonated beverages

Table 8. pH, calcium and fluoride ion concentrations of carbonated beverages

Beverage	pH *mean (SD)*	Calcium mmol / l *mean (SD)*	Fluoride ppm *mean (SD)*	Fluoride mmol / l *mean (SD)*
Elephant Orange crush®	2.91 (0.14)	1.12 (0.05)	0.069 (0.013)	0.004 (0.000)
My Orange®	3.00 (0.29)	0.52 (0.08)	0.043 (0.010)	0.002 (0.000)
Mirinda®	2.69 (0.21)	0.57 (0.11)	0.198 (0.011)	0.005 (0.000)
Fanta®	2.70 (0.17)	0.55 (0.01)	0.109 (0.016)	0.006 (0.000)
My Cream Soda®	3.10 (0.13)	0.35 (0.06)	0.038 (0.009)	0.002 (0.000)
Ole Cream Soda®	3.29 (0.22)	0.54 (0.04)	0.196 (0.015)	0.010 (0.000)
Elephant Cream Soda®	3.10 (0.21)	0.53 (0.02)	0.038 (0.005)	0.002 (0.000)
Elephant Necto®	2.80 (0.12)	0.69 (0.09)	0.070 (0.022)	0.004 (0.001)
Elephant Ginger Beer®	3.39 (0.19)	0.78 (0.04)	0.061 (0.010)	0.003 (0.000)
My Ginger Beer®	2.99 (0.16)	0.49 (0.03)	0.040 (0.004)	0.002 (0.000)
Sprite®	2.99 (0.27)	0.40 (0.05)	0.098 (0.008)	0.005 (0.000)
My Lemon®	3.28 (0.31)	0.32 (0.04)	0.038 (0.009)	0.002 (0.000)
Seven – Up®	3.39 (0.26)	0.55 (0.03)	0.211 (0.013)	0.011 (0.001)
Shaa Cola®	2.78 (0.22)	0.58 (0.06)	0.079 (0.020)	0.004 (0.001)
Coca Cola®	2.30 (0.11)	0.58 (0.09)	0.122 (0.014)	0.006 (0.000)
My Cola®	2.79 (0.17)	0.35 (0.03)	0.048 (0.011)	0.002 (0.000)
Pepsi®	2.43 (0.19)	0.79 (0.07)	0.142 (0.023)	0.007 (0.001)

The pH values and calcium and fluoride ion concentrations of some commonly consumed carbonated beverages are given in Table 8. The pH values of the beverages analysed ranged between 2.30 (Coca Cola®) and 3.39 (Elephant Ginger Beer® / Seven-up®). Calcium concentrations of beverages were within the range of 0.32 mmol/l (My Lemon®) and 1.12

mmol/l (Elephant Orange Crush®). Fluoride concentrations ranged from 0.038 ppm (My Cream Soda®, Elephant Cream Soda®, My Lemon®) to 0.211 (Seven-Up®).

Awareness about tooth wear /dental erosion among children

Table 9. Distribution of children according to awareness about tooth wear/ dental erosion (n= 1123)*

	Number	Percentage (of total sample)
Heard of tooth wear / erosion		
Yes	1023	91.1
No	90	8.8
Sugar causes decay		
Yes	1012	90.1
No	4	9.4
Don't know	106	9.4
Sugar causes erosion		
Yes	604	53.8
No	184	16.4
Don't know	278	24.8
Acid causes tooth decay		
Yes	953	84.9
No	69	6.1
Don't know	100	8.9
Acid causes erosion		
Yes	211	18.8
No	444	39.5
Don't know	460	41.0
Dentist educated me on erosion		
Yes	93	8.3
No	1023	91.1
Like to know about erosion		
Yes	1112	99.0
No	0	0.0

**Totals in different categories do not add up to 1123 because there were missing values.*

Ninety-one-per cent of children had stated that they have heard of tooth wear / dental erosion. However, 54% had stated that sugar is the causative factor for erosion. Only 19% of the sample were aware that acid is the cause of dental erosion. Eight-per-cent of the children mentioned that their dentists had educated them on dental erosion. Almost all the children were keen to know more about tooth wear / dental erosion (Table 9).

Discussion

Except for a few population based national level surveys (O'Brian, 1994; Hinds and Gregory, 1995; Williams *et al*, 1999), most epidemiological studies on tooth wear have been confined to small geographic areas (Jones and Nunn, 1995; Al-Majed, Maguire and Murray, 2002) while others have been carried out in convenient samples (Wiktorsson, Zimmerman and Angmar-Mansson, 1997; Johansson *et al*, 1996; Bartlett *et al*, 1998). The present study was carried out in the Colombo district, which is the most densely populated district in Sri Lanka. The Colombo district has a population of 2,234,289 of which 605,492 are under 18 years of age (Department of Census and Statistics, 2001). Moreover, the Colombo district was selected as the study area because of its ethnic diversity and availability of a mix of government, private and international schools.

Milosevic, Bardsley and Taylor (2004) emphasized the importance of studying large samples in epidemiological studies of tooth wear in order to capture sufficient number of cases for further analysis for risk indicators. This was taken into consideration when determining the sample size. Sufficient allowances were made for the design effect and non-response. Although a simple random sampling technique has been employed to select the sample in most epidemiological studies of tooth wear (Caglar *et al*, 2005; Johansson et al, 1996), considering the large extent of the study area and other logistic difficulties like obtaining accurate sampling frames from the education authorities, it was decided to employ a cluster sampling technique combined with 'probability proportionate to size' technique. This reduced the extensive travelling involved to some extent while ensuring a fair chance for every school within the district to be selected to the study sample according to the proportion of students. This was further facilitated by maintaining the cluster size as low as 15 and including a large number of clusters in the study sample ensuring sufficient coverage of the whole district. The final sample consisted of 66 clusters from 51 government schools, 11 clusters from 11 private schools and 3 clusters from 3 international schools and is a representative distribution of the different types of schools based on the proportion of students.

Number of indices have been developed by different authors to measure tooth wear and dental erosion among different populations. Of them, Tooth Wear Index of Smith and Knight (1984a) is the commonly used index in epidemiological research. Having considered all the available indices on tooth wear, it was decided to use a modified version of the Tooth Wear Index by Smith and Knight (1984a) as it was found to be appropriate to meet the objectives of the study. In most epidemiological studies on tooth wear, clinical examination has been confined to the anterior teeth and / or molar teeth (Dugmore and Rock, 2004a; O'Brian, 1994, Johansson *et al*, 1996; Bradsley, Tailor and Milosevic, 2004). However, in the present study, in order to obtain a detailed picture about the distribution of tooth wear, all teeth except the third molars were examined. Buccal / labial, incisal / occlusal, and lingual / palatal surfaces were examined in each tooth. The principal investigator, being the sole examiner of the study participated in calibration exercises with a Consultant in Restorative Dentistry on the use of the tooth wear index until a satisfactory level of agreement was achieved. Cohen's Kappa statistic showed that a satisfactory level of agreement ($0.75<k$) was achieved for all tooth surfaces in relation to codes 0, 1, 2 and 3 of the Tooth Wear Index of Smith and Knight (1984a) and was similar to the kappa values achieved for inter-examiner variability in previous studies (Al-Malik, Holt and Bedi, 2002; Lussi *et al*, 1991)

A comprehensive questionnaire was developed to obtain information about socio-demographic, dietary and behavioural risk indicators of tooth wear / dental erosion. Two questionnaires previously used in the United Kingdom were used as a guideline in preparing the questionnaire (Milosevic, Lennon and Fear, 1997; Bardsley, Taylor and Milosevic, 2004). The commonly consumed carbonated beverages and acidic food items identified in the pre-test were included in the questionnaire. There is sufficient evidence to show that the 'frequency' and the manner in which acidic food or drink is consumed is more important than the overall quantity in developing toothwear (Bartlett, 2005). Therefore, in the present study, 'quantity' of acidic food or beverages consumed was not assessed. Although the 'frequency' of intake of acidic food items and carbonated beverages were recorded in a 7-point scale, for the purpose of analysis, it had to be dichotomised as 'less than once a week' and 'more than once a week', owing to small numbers in most categories.

In analyzing the risk indicators of tooth wear and dental erosion, most researchers have used logistic regression models in addition to bivariate analysis (Dugmore and Rock, 2004b; Williams *et al*, 1999; Al-Malik, Holt and Bedi, 2001; Wiegand *et al*, 2002). In the present study, individual effects of risk indicators on prevalence and severity of tooth wear were assessed using bivariate analysis. A multivariate logistic regression analysis was carried out in order to assess the independent effects of significant risk indicators on the prevalence of tooth wear.

Analysis of erosive potential of carbonated beverages has also been a topic of interest among researchers on tooth wear and dental erosion. In addition to assessing acidity (pH), concentration of calcium, fluoride and phosphate ions have been assessed to determine the protective effects (Larsen and Nyvad, 1999; Lussi et al, 2000; Brown et al, 2007; Jensdottir, Bardow and Holbrook, 2005). A laboratory analysis was included in the present study in which seventeen brands of carbonated beverages were analysed in order to assess the pH, calcium and fluoride ion concentrations. Of the beverages analysed, six were produced by multi-national companies (Coca Cola®, Fanta®, Sprite®, Pepsi®, Seven-up® and Mirinda®) while others were produced by local companies. To the best of knowledge, this is the first study where laboratory analysis to assess the erosive potential of beverages was incorporated into a large epidemiological survey on tooth wear.

According to the literature there are only two studies that assessed the awareness about tooth wear and dental erosion among children and adolescents. Dugmore and Rock (2003c) assessed awareness about tooth wear and dental erosion among 12-year-old children from United Kingdom using a self-administered questionnaire. Milosevic, Bardsley and Taylor (2004) in their study, assessed the same among 14-year-olds. In the present study, the final part of the questionnaire was intended to gather information pertaining to awareness about tooth wear and dental erosion among the study sample.

Although all the subjects (1200) returned the completed self-administered questionnaire, only 1123 of them participated in the oral examination. Therefore, the response rate for the oral examination (the percentage of children who consented for the oral examination after administering the questionnaire) was 93.6% which is fairly high when compared with that of the pilot study (77.0%). This high response rate was achieved through proper motivation of subjects and by building confidence among the subjects about the safety of the examination procedure and sterility of instruments.

The analysis is based on subjects who participated in both the oral examination and who completed the questionnaire (1123). Of them, 53% were girls, accounting for a sex ratio of 89.7 which is below the sex ratio of the Colombo district (Department of Census and Statistics, 2001). Thus, there was a slight overrepresentation of girls in the study sample (Table 5.1). However, it is observed that the ethnic composition of the study sample was reasonably representative of the general population of the Colombo district.

Prevalence of tooth wear

According to the findings, the prevalence of tooth wear among this adolescent population was 22.4%. This prevalence is within the range of 22% to 28% reported for adolescents in the United Kingdom (Williams *et al*, 1999; O'Brian, 1994), Iceland (Arnadottir, Saemundsson and Holbrook, 2003) and Turkey (Caglar *et al*, 2005). On the other hand, Bartlett *et al* (1998) and Dugmore and Rock (2004a) in their studies have reported that prevalence of tooth wear were 57% and 59.7%, respectively. The prevalence of dentine wear in the present study was 9% and very low when compared with those studies of Al-Dlaigan, Shaw and Smith (2001a) and Bardsley, Taylor and Milosevic (2004) who had reported that prevalence of dentine wear were 52% and 53%, respectively.

It is possible that the variations in prevalence rates observed between studies are mainly due to methodological differences between studies rather than due to the differences in the burden of disease *per se*. These include the use of different indices to record tooth wear, the differences in the types of teeth considered for recording tooth wear and also the variations in the age groups considered.

Severity of tooth wear

On the average, 3.54 surfaces were affected by tooth wear per subject, while 2.57 and 0.97 surfaces per subject were affected by enamel wear and dentine wear, respectively. Of those affected by tooth wear, a majority had only one or two affected surfaces. All students who presented with the dentine wear had at least one other tooth surface affected by enamel wear. Severe forms of tooth wear involving the dentine of more than 50 surfaces was seen in a very small percentage (0.3% of the total sample). However, tooth wear extending up to the dental pulp was not observed in these adolescents. Previous studies have not attempted at determining the severity of tooth wear. Hence, there are no comparable data on the severity of tooth wear. A reason why previous studies have not attempted at assessing the severity of tooth wear may be due to the fact that these studies have used partial recordings rather than full mouth recordings of tooth wear. As partial recording concentrates on a few teeth, it could underestimate the true extent of the condition.

Distribution of tooth wear

Conforming with other studies (Lussi *et al*, 1991; Bardsley, Taylor and Milosevic, 2004), tooth wear lesions showed a symmetrical distribution in both upper and lower arches. Occlusal surfaces of posterior teeth were the most affected surfaces in both upper and lower arches. The first molar was the most commonly affected tooth. As first molars are the first to erupt, they can be exposed to risk factors of tooth wear for a considerably long period of time. These findings are in agreement with those studies conducted in the United Kingdom,

Thailand, Nigeria and Switzerland (Bradsley, Taylor and Milosevic, 2004; Chuajedong *et al*, 2002; Bartlett *et al,* 1998; Milosevic, Young and Lennon, 1994; Ogunyinka, Dosumu and Otuyemi, 2001; Lussi *et al* , 1991).

However, in a study conducted in Finland it was observed that the upper anterior teeth showed the highest prevalence of erosion (Jarvinen, Rytomaa and Meurman, 1992). It is noteworthy that the sample of that study was not drawn from the general population but they were patients diagnosed with dental erosion and referred by dentists practicing in Helsinki to the authors for further management.

Labial surfaces were affected by enamel wear mainly in the anterior teeth of the upper arch. Tooth wear was not seen in the lingual surfaces of the lower arch. In their study on a Swiss population, Lussi *et al* (1991) described a similar pattern of distribution of tooth wear. However, the distribution of tooth wear observed in the present study cannot be compared with the findings of published studies, since the assessment of tooth wear in those studies have been confined to the upper anterior teeth and/or first molars rather than to the full dentition (Dugmore and Rock, 2004a; O'Brian, 1994, Johansson *et al*, 1996).

Risk indicators of tooth wear

Apart from assessing the prevalence, severity and distribution of tooth wear, the present study also attempted at establishing the associations between tooth wear and potential risk indicators. Initially bivariate analysis was carried out. Associations between *prevalence* of tooth wear (enamel wear, dentine wear and tooth wear) and potential risk indicators were investigated. Moreover, as a full mouth recording was done for each subject, it was possible to analyse the associations between *severity* of tooth wear and potential risk indicators as well. Since the number of tooth surfaces affected by tooth wear in the sample was not normally distributed and showed a positively skewed distribution, non-parametric tests had to be used to compare differences between groups (Mann-Whitney U test and the Kruskal-Wallis test).

It is noteworthy that in most studies, authors have confined their analysis to the associations between *prevalence* of tooth wear and potential risk indicators (Al-Malik, Holt and Bedi, 2001; Dugmore and Rock, 2004b; Al-Dlaigan, Shaw and Smith, 2001b; Milosevic, Bardsley and Taylor, 2004). However, as the present study also assessed the associations between *severity* of tooth wear and the potential risk indicators, this study could be considered an advancement on previous studies.

Tooth wear and acidic food

The influence of a wide range of food items on tooth wear was assessed in this study. Of the food items considered, consumption of oranges, apples and sauce more than once a week showed a significant association with both the *prevalence* and *severity* of tooth wear. Consumption of tamarind more than once a week was significantly associated with the *prevalence* of tooth wear. Furthermore, *prevalence* of dentine wear was significantly associated with consumption of oranges, apples and sauce more than once a week. These findings are consistent with the findings from the previous studies (Al-Dlaigan, Shaw and

Smith, 2001b; Sirimaharaj, Messer and Morgan, 2002; Lussi *et al*, 1991, Harding *et al*, 2003; Milosevic, Bardsley and Taylor, 2004; Rees, 2004; Kunzel, Cruz and Fischer, 2000; Jarvinen, Rytomaa and Heinonen, 1991). However in the multiple logistic regression analysis, only consumption of oranges more than once a week emerged as a significant predictor of the prevalence of tooth wear.

Tooth wear and acidic beverages

Of the beverages considered, consumption of Coca Cola® and Ginger Beer more than once a week showed significant associations with the *prevalence* and *severity* of tooth wear. Moreover, *prevalence* of dentine wear was significantly associated with consumption of Coca Cola®, Ginger Beer and natural fruit juice more than once a week. Consumption of Fanta® more than once a week was significantly associated with the *prevalence* of enamel wear. In the multiple logistic regression analysis, consumption of oranges and Coca Cola® more than once a week showed a significant association with the *prevalence* of tooth wear and consumption of Coca Cola® more than once a week showed a significant association with the *prevalence* of dentine wear. *Prevalence* of enamel wear was significantly associated with consumption of Fanta® more than once a week. These findings are consistent with previous research findings where carbonated and other acidic beverages have shown to be risk indicators of tooth wear and dental erosion (Dugmore and Rock, 2004b; Al-Dlaigan, Shaw and Smith, 2001b; Milosevic, Lennon and Fear, 1997; Al-Majed, Maguire and Murray, 2002; Shaw and Smith, 1998; Jarvinen, Rytomaa and Heinonen, 1991; Linnett and Seow, 2001; Milosevic, Bardsley and Taylor, 2004).

Tooth wear and dietary behaviours

Several dietary behaviours have found to be linked to tooth wear and dental erosion, some of which are unusual or abusive in nature (Shellis *et al*, 2005; Johansson, Lingstorm and Birkhead, 2002; Rees, 2004; Abrahamsen, 2003). In the present study, subjects were questioned about several dietary behaviours identified as potential risk indicators for tooth wear in other studies. However, none of them showed significant associations with the prevalence / severity of tooth wear in the bivariate analysis. Only the method of drinking fruit juices was significantly associated with the *prevalence* of dentine wear in the bivariate analysis. However, it lost its significance in the multiple logistic regression analysis.

Laboratory analysis of carbonated beverages

Laboratory analysis of carbonated beverages revealed startling findings. The pH value - the major determinant of the erosive potential - of most of these beverages was low when compared with the findings from other studies. Compared to the pH values reported in the literature, the pH value of Coca Cola® samples analysed in the present study (2.30) was the lowest. Moreover, calcium and fluoride concentrations in Coca Cola® were found to be low when compared to other studies (Jager *et al*, 2008; Lussi *et al*, 2000; Zero and Lussi, 2005; Attin *et al*, 2005; Lussi, Jaeggi and Zero, 2004). Research has shown that calcium and fluoride ions could reduce the erosive potential of acidic beverages (Jensdottir, Bardow and Holbrook, 2005; Attin *et al*, 2005). Therefore, with a low pH value and low levels of calcium and fluoride, it is logical to assume that the local product of Coca Cola® carries a high erosive

potential. This is substantiated by the fact that Coca Cola® emerged as a significant predictor of prevalence of tooth wear in the multiple logistic regression analysis. Also the pH values of Fanta® and Pepsi® in the present study were lower than pH values for Fanta® and Pepsi® reported in other studies.

Table 10. Comparison of pH, calcium and fluoride ion concentrations of carbonated beverages reported in various studies with the findings of the present study

	pH	Calcium m mol/ l	Fluoride ppm	Fluoride m mol/ l
Coca Cola®				
Larsen and Nyvad (1999)	2.40	0.26	-	0.20
Lussi *et al* (2000)	2.60	0.84	0.13	0.007
Lussi, Jaeggi and Zero (2004)	2.6	0.84	0.13	-
Jensdottir, Bardow and Holbrook (2005)	2.59	-	-	-
Attin *et al* (2005)	2.53	0.94	-	0.011
Zero and Lussi (2005)	2.60	0.8	0.131	-
Jager *et al* (2008)	2.47	0.08	-	-
Present study	**2.30**	**0.58**	**0.122**	**0.006**
Fanta®				
Lussi, Jaeggi and Jaeggi-Scharer (1995)	2.86	-	0.05	0.003
Larsen and Nyvad (1999)	2.86	0.38	-	0.20
Lussi, Jaeggi and Zero (2004)	2.9	0.75	0.05	-
Jager *et al* (2008)	3.03	0.06	-	-
Present study	**2.70**	**0.55**	**0.109**	**0.006**
Sprite®				
Lussi, Jaeggi and Jaeggi-Scharer (1995)	2.79	-	0.17	0.009
Larsen and Nyvad (1999)	2.98	0.36	-	0.58
Lussi *et al* (2000)	2.64	0.15	0.04	0.002
Lussi, Jaeggi and Zero (2004)	2.9	0.26	0.06	-
Attin *et al* (2005)	2.69	1.25	-	0.013
Present study	**2.99**	**0.40**	**0.098**	**0.005**
Pepsi®				
Larsen and Nyvad (1999)	2.53	0.09	-	0.45
Lussi, Jaeggi and Zero (2004)	3.1	0.9	0.04	-
Present study	**2.43**	**0.79**	**0.142**	**0.007**
Seven-up®				
Hara and Zero (2008)	3.20	0.07	-	0.003
Present study	**3.39**	**0.55**	**-**	**0.011**

Awareness about tooth wear and dental erosion

It was evident from the results that the knowledge about tooth wear and dental erosion among these adolescents was low. Although 91% of the students reported that they have heard of tooth wear and dental erosion, only 19% knew that 'acid' is the cause of tooth erosion. Moreover, 54% identified 'sugar' as the causative factor of dental erosion indicating poor knowledge about the aetiology of this condition. In their studies, Dugmore and Rock (2003c) and Milosevic, Bardsley and Taylor (2004) had reported that 40- 44% had cited sugar as the causative agent of tooth erosion. Only 8.3% of the students in the present study reported that they were educated by their dentists regarding tooth wear and dental erosion. According to Dugmore and Rock (2003c) 8.1% adolescents from the UK have received an explanation about or advice in relation to tooth wear and dental erosion.

In summary, the present study which was the first to assess the burden of tooth wear among adolescents in Sri Lanka found that 22% of the population was affected by tooth wear with nearly 9% having at least one tooth with wear extending up to the dentine. When the severity of wear was considered, 3.54 surfaces per student were affected by tooth wear. Number of tooth surfaces affected by tooth wear showed a positively skewed distribution in the sample. This indicates that severe forms of tooth wear involving large number of surfaces is restricted to a small proportion of the sample.

In both upper and lower dental arches, tooth wear lesions showed a symmetrical distribution. Subjects with tooth wear lesions extending up to the dentine also had several 'enamel wear' lesions. Isolated (localized) single lesions extending up to the dentine were not observed in any subject.

Of the potential risk indicators considered, monthly family income of over 30,000 rupees per month, consumption of Coca Cola® more than once a week and consumption of oranges more than once a week were retained in the final model of logistic regression analysis of prevalence of *tooth wear*. Furthermore, attending a private or international school and consumption of Coca Cola® more than once a week emerged as significant predictors of *dentine wear*. Consumption of Fanta® more than once week emerged as a significant predictor of *enamel wear*.

The results of the present study indicate that tooth wear caused by 'attrition' and 'abrasion' was rare among these adolescents. Variables related to attrition and abrasion such as bruxism and frequency of tooth brushing failed to show significant associations with tooth wear. Therefore it is reasonable to conclude that 'dental erosion' is the commonest type of tooth wear observed among these adolescents. This is in agreement with previous findings where dental erosion was found to be the commonest type of tooth wear observed among young individuals (Harley, 1999; Jarvinen, Rytomaa and Heinonen, 1991; Nunn, 1996; Shaw and Smith, 1998; Dugmore and Rock, 2004b).

It should be noted that in the multiple logistic regression analyses, the total variance in different types of tooth wear explained by the models were low. It was 2% (Pseudo R^2 = 0.02), 26% (Pseudo R^2 = 0.26) and 10% (Pseudo R^2 = 0.10) for enamel wear, dentine wear and tooth wear, respectively. Apart from the variables considered in this study, this shows that there are other variables that may influence the development of tooth wear in adolescents. It is possible that host factors such as salivary flow rate, buffering capacity,

anatomy of oral structures and tooth composition may have some influence on tooth wear. However, analyses of these factors were beyond the scope of this study. Due to the multifactorial aetiology of tooth wear, many researchers have encountered such problems in their studies. This may be the reason that led Rock (2004) to comment that the complexity of the aetiology of tooth wear has made it difficult to demonstrate strong associations with the suspected aetiological factors.

Based on the findings of this study it could be concluded that acidic food / drinks, particularly consumption of carbonated beverages (Coca Cola®, Fanta®) had played a significant role in the development of tooth wear in these adolescents. This association was observed despite the fact that the consumption of carbonated beverages among the adolescents of the present study was less when compared to adolescents from developed countries (Milosevic, Bardsley and Taylor, 2004; Dugmore and Rock, 2004b; Al-Dlaigan, Shaw and Smith, 2001b). A possible explanation for this may be that the pH levels of many locally available beverages are much lower (higher erosive potential) than the reported pH values of beverages sold in those countries. Moreover, it was evident that knowledge about causative agents of tooth wear and dental erosion was poor among these adolescents. Therefore, the present study highlights the importance of educating school children about the harmful effects of the acidic diet on oral health. There is a need for public oral health policy leading to restriction of marketing and consumption of carbonated beverages at least in the school environment. School canteen policy should be strengthened in this respect.

Conforming to other studies (Bardsley, Taylor and Milosevic, 2004; Peres *et al*, 2005), high socio-economic status (attending private and international schools, monthly income exceeding Rs. 30,000) was associated with tooth wear among these adolescents. Bardsley, Taylor and Milosevic (2004), having found that the risk of tooth wear increased with affluence, endorsed it as a 'disorder of affluence'.

This study was the first to comprehensively assess tooth wear among adolescents in a developing country. Findings of the study are in agreement with those from developed countries where tooth wear / dental erosion is shown to be an emerging health problem due to changing eating and drinking habits of teenagers and young adults, associated with increasing socio-economic standards. This provides evidence for the 'epidemiological transition' in which the traditional 'infectious / communicable' diseases are now being replaced by 'lifestyle-related' diseases. However, tooth wear is a preventable condition similar to many other dental and oral diseases such as dental caries, periodontal diseases and oral cancers. Secondary and tertiary prevention of tooth wear involves costly restorative procedures which can cause severe economic burden to the individual as well as the country. Thus, primary prevention of tooth wear should be the important goal and joint efforts by different authorities namely health, education and media may be important in achieving this goal.

Conclusions

Prevalence of tooth wear

It was evident from the results that the prevalence of tooth wear was 22.4%. Prevalence of tooth wear confined to enamel was 13.7 % while the prevalence of tooth wear extending up to dentine was 8.7%.

Severity of tooth wear

A total of 3972 tooth surfaces were affected by tooth wear in the total sample. The mean number of tooth surfaces affected by tooth wear per student was 3.5 $\pm$ 10.5. There were 2885 surfaces where tooth wear was confined to the enamel in the total sample. The mean number of tooth surfaces affected with only enamel wear was 2.6 $\pm$ 7.0 per student. Dentine wear was seen in 1087 surfaces in the total sample, with a mean of 1.0 $\pm$ 5.4 surfaces per student.

Of those affected by tooth wear, a majority (32%) had only one surface affected. In nearly 6%, 51-60 surfaces were affected. Of those with tooth wear lesions confined to enamel, nearly 32% had 1-2 surfaces affected while 11% had 31-40 surfaces affected. Of those with dentine wear, 48% had lesions in 1-2 surfaces.

Distribution of tooth wear lesions

Of the total surfaces in the upper arch, 4.2% of surfaces were affected by tooth wear. Enamel wear was seen in 3.2% of the surfaces while dentine was affected in 1.0% of the surfaces.

Of the total surfaces in the lower arch, 4.4% affected by tooth wear. Enamel wear was observed 3.0% of the surfaces while dentine wear was seen in 1.4% of the surfaces.

Teeth in the upper arch were more affected by enamel wear (3.2%)than teeth in the lower arch (3.0%) while dentine wear was more in the lower arch (1.4%)than in the upper arch (1.0%). Tooth wear lesions were symmetrically distributed in the dental arches.

Association between tooth wear and potential risk indicators

1. **Multiple logistic regression analysis for prevalence of enamel wear**

Of all the independent variables that were significant in the bivariate analysis, only consumption of Fanta® emerged as a significant predictor of prevalence of *enamel wear*. Those who consumed Fanta® at least once a week were 1.6 times more likely to develop enamel wear (95% CI = 1.05 – 2.44, $p = 0.03$) than those who did not. The total variance in enamel wear explained by the multiple logistic regression model was 4% (Pseudo $R^2 = 0.04$).

2. **Multiple logistic regression analysis for prevalence of dentine wear**

Only two of the independent variables retained in the model were significantly associated with the prevalence of *dentine wear*. Consumption of Coca-Cola® at least once a week with an odds ratio of 6.05 (95% CI = 1.92 – 19.00, $p = 0.002$) had the strongest association with dentine wear. Students of private or international schools were 3 times more likely to have

dentine wear than those attending government schools. The total variance in dentine wear explained by the multiple logistic regression model was 26% (Pseudo $R^2 = 0.26$)

3. Multiple logistic regression analysis for prevalence of tooth wear

Three independent variables retained in the model were significantly associated with prevalence of *tooth wear*. Monthly family income exceeding Rs. 30,000 with an odds ratio of 2.01 (95% CI = 1.10 – 3.67, $p = 0.02$) had the strongest association with tooth wear. Consumption of oranges at least once a week (OR = 1.83, 95% CI = 1.00-3.33, $p = 0.048$) and consumption of Coca-Cola® at least once a week (OR = 1.88, 95% CI = 1.06-3.35, $p = 0.03$) were also significantly associated with tooth wear. The total variance in tooth wear explained by the multiple logistic regression model was 10% (Pseudo $R^2 = 0.10$).

Chemical analysis of carbonated beverages

The pH values of the beverages analysed were within the range of 2.30 (Coca Cola®) and 3.39 (Elephant Ginger Beer®). Calcium concentrations of beverages were within the range of 0.32 mmol/l (My Lemon®) and 1:12 mmol/l (Elephant Orange Crush®). Fluoride concentrations ranged from 0.038 ppm (My Cream Soda®, Elephant Cream Soda®, My Lemon®) to 0.211 (Seven-Up®).

Awareness about tooth wear /dental erosion among children

Ninety-one-per cent of children had stated that they have heard of tooth wear / dental erosion. However, 54% cited 'sugar' as the causative factor for erosion. Only 19% of the sample were aware that 'acid' is the cause of dental erosion. Moreover, only 8% of the children mentioned that their dentists had educated them on dental erosion.

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SECTION 4

IMPACT OF RESEARCH RESULTS:

i) Relevance of results achieved to scientific advancement

The study revealed that identifying high risk groups for tooth wear and dental erosion should be considered a priority in the national level oral health programmes. Assessment of tooth wear and dental erosion among children, adolescents and adults should be incorporated to future National Oral Health Surveys.

In routine dental practice, tooth wear lesions could be left unnoticed or undiagnosed due to lack of attention and awareness. Dental profession should be made aware of this emerging dental problem particularly among adolescents. Knowledge among dental surgeons should be updated with respect to the aetiology of tooth wear. Moreover, dental surgeons should be motivated to screen and diagnose patients with initial stages of tooth wear and dental erosion, in their routine dental practice. Once such cases are diagnosed, oral health education messages with special emphasis on healthy dietary behaviours should be delivered to the patient, in order to prevent further progression of the condition.

For diagnosing individual cases, universally accepted diagnostic criteria should be developed with regards to tooth wear. Dental surgeons should strictly adhere to these criteria during clinical practice. Moreover, dental profession should agree upon a suitable index to be used in epidemiological studies on tooth wear. This will facilitate comparison of findings from different studies conducted on different populations from different parts of the world. Once there is agreement on a suitable index to record tooth wear, it can be included in the WHO Oral Health Surveys – Basic Methods.

Further research should be encouraged to investigate the complex aetiology of tooth wear among adolescents in Sri Lanka. The present study could form a basis for future research. There may be other acidic food items consumed by these adolescents which were not revealed by this study. Furthermore, there can be other aetiological factors linked with higher socio-economic standards, which need further investigations.

ii) Relevance of results achieved to national/socio-economic development

Tooth wear / dental erosion and its complications leads to a considerable economic burden to a country in terms of cost of treatment, loss of school days of children and loss of man-hours in the work force. Since it was evident that consumption of carbonated beverages carries a risk of tooth wear, there is a need to control consumption of such beverages, particularly by adolescents and children. Public awareness campaign should be launched addressing these target groups, highlighting

the harmful effect of these substances. Legislative support should be sought to regulate the composition of carbonated beverages manufactured within the country. Moreover, regular monitoring of the composition of these beverages should be carried out by the relevant authorities.

Since the results revealed that the knowledge on tooth wear and dental erosion is poor among adolescents, there is a need to educate them on the aetiology and prevention of tooth wear and dental erosion. Combined actions of health and education authorities are required in this respect. School children should be educated with respect to various acidic food items and behaviours that can lead to tooth wear and dental erosion. Health education can be delivered at any setting whether a dental clinic or a classroom. Dental surgeons working in adolescent dental clinics can be used for this process.

iii) Dissemination/application of research output

This research highlights the importance of incorporating prevention of tooth wear and dental erosion into the School Health Programme. During this study investigators observed that acidic food items, mainly carbonated beverages were freely available in most of the school canteens. The *Healthy School Canteen Policy* - which has not been put into practice to date - has identified 'discouraging the promotion of unhealthy food items within the canteen and school premises' as a strategy to achieve its objectives (Ministry of Education, 2006). It is the duty of both education and health authorities to implement this policy which was recognized as an integral component of the health promoting school.

SECTION 5

Miscellaneous

i) List of major equipment acquired during the project period and their functionality

Nil

ii) List of publications/communications arising from the project and/or presentations made at seminars, workshops etc.

Nil

SECTION 6

Summary Statement of Expenditure (indicate under Personnel, Equipment, Consumables, Travel and Subsistence and Miscellaneous)

		Funds received (Rs.)	Total expenditure (Rs.)	Balance available (Rs.)
Personnel	Research student	-	-	-
	Technical assistant	150,000/=	150,000/=	-
	Other	70,520/=	70,333.28	186.72
Equipment	Foreign	-	-	-
	Local	-	-	-
Consumables	Foreign	-	-	-
	Local	16,605/=	16,595/=	10/=
Travel and subsistence		24,250/=	24,016/=	234/=
Miscellaneous		94,435/=	93,151/=	1284/=
TOTAL		355,810/=	354,095.28	1,714.72

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