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Effects of Excessive Intake of Fluoride in People Living in Endemic Areas in Sri Lanka

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Section 1

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II) Title of the Project: Effects of excessive intake of fluoride in people living in endemic areas in Sri Lanka

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V) Institute(s) where research was being carried out:
Dental Institute, Ward Place, Colombo7

VI) Date of award: 23rd December 2005 (Due to practical issues the project was initiated on 1st March 2006)

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Section 2

Executive Summary of the Project

Health hazards due to excessive ingestion of fluoride are well documented such as dental, soft tissue and skeletal fluorosis. In addition, there is emerging evidence for potential renal damage associated with excessive fluoride intake. Studies have also shown that malnutrition could aggravate fluoride toxicity. Excess fluorides in ground and surface water in some parts of the country pose a serious water quality issue. There are no studies conducted on non dental effects of excessive fluoride ingestion. Therefore, the present study was aimed at determining the prevalence and severity of fluorosis in people living in endemic areas, investigating the relationship of nutritional status of people with the occurrence of fluorosis and introduction of a simple defluoridation method and to assess its effectiveness.

The study area was Thambuttegama MOH area. The sample consisted of 750 people (382 children aged 12-15 years and 368 adults aged 35-44 years) selected randomly from 13 PHM areas. Data were collected by an interviewer administered, pre-tested questionnaire, clinical oral examination, measurement of body weight and height, performance of three physical tests and analyses of drinking water and early morning spot sample of urine. Urine fluoride levels were analyzed among a subsample 278 (145 children and 133 adults). The majority (85.8%) of children and 49.3% of adults had dental fluorosis as assessed by TF index. Moreover, 23.2% of children and 11.4% of adults carried a severe burden of dental fluorosis with opacities and surface losses of enamel. There were no statistically significant associations between nutritional status assessed by BMI and occurrence of dental fluorosis and skeletal fluorosis: assessed by severity of self reported symptoms and performance of three physical tests. Similarly, there were no statistically significant relationships among estimated minimum daily intake of fluoride and occurrence of dental and skeletal fluorosis. Moreover, the Community Fluorosis Index (CFI) was discernibly high for children (2.24) and also for adults 1.34 thus illustrated that dental fluorosis as *a public health problem* for inhabitants in Thambuttegama and especially among 12-15 year old adolescent children. However, there was no evidence for skeletal fluorosis to be considered as a public health problem.

Therefore, in conclusion fluoride filters using newly burnt bricks could be considered as an effective method of de-fluoridation for endemic areas of fluorosis. Nevertheless, after 6 months, of their distribution there was evidence for declined number of users (30% reduction) due to acquired tap lines and subsequent substitution of source of water for household use. In addition, the number of *effective users (fluoride levels in filtered water <0.8 mg/l)* appeared to be lowering down from 51.2% to 36.4% which could be attributed to practical problems such as difficulties in getting regular supply of bricks. The present study denotes one of the first attempts to assess the effectiveness of fluoride filters as a simple de-fluoridation method for people who consume excess amounts of fluoride in an endemic area of fluorosis in Sri Lanka. It had the added strength of two assessments and a long- term follow period extended

up to 14 months after distribution of filters thus giving rise to many practical implications of its findings. Feedback from recipients is fundamental to assessing effectiveness of these de-fluoridation methods which should compliment assessment of fluoride levels in filtered water based on an upper threshold limit as used in this study. Importantly, there are basic issues such as ensuring a regular supply of bricks and making improvements to the design of filters which need to be considered in order to empower rural communities already burdened with many other aspects of their daily living in order to sustain their commitment to use fluoride filters.

The present study constituted a relatively comprehensive and novel approach to assess the effects of excessive ingestion of fluorides in people living in an endemic area and long-term effectiveness of fluoride filters. Nevertheless, its findings related to prevalence of symptoms related to fluorosis merit further investigations with methodological refinements. Sustainability of the fluoride filter use is a vital issue which needs special concern.

Section 3

Report in detail

I) Introduction/background

Fluoride plays the dual role of being related to one of the ten public health achievements in the last century (CDC, 1999) at optimal levels in one aspect while being a putative causative factor for a spectrum of diseases in excess. Its beneficial as well as toxic effects in humans have important public health implications. Burt (1992),reported that the dose of 0.05-0.07 mg/F/kg body weight / day as the limit dose for epidemiological studies for prevention and control of dental caries. However, long-term exposure to higher amounts results in deleterious effects on tooth enamel and bone. Fluorosis is an endemic disease resulting from excess intake of fluoride either via drinking water, food or dentifrices (Rozier, 2004). Ground waters with high fluoride concentrations occur in many areas of the world including large parts of Africa, China, the Middle east and Southern Asia (India, Sri Lanka) (WHO,1994).

Depositions of excessive fluorides during the period of tooth development give rise to altered tooth structure called as *'dental fluorosis'* which is an irreversible condition. Clinical presentation of dental fluorosis ranges from barely noticeable white flecks to an aesthetically unacceptable generalized opaque and chalky appearance with confluent pitting and staining of the tooth surfaces (WHO, 1994). While dental fluorosis can be easily recognized, the skeletal involvement is not clinically obvious as excessive deposition of fluoride on skeletal tissues is a gradual continuing process. With time, affected individuals gradually develop restrictions of movements and stiffness of joints (WHO, 1994). In addition, studies have shown that excessive ingestion of fluorides could cause soft tissue manifestations such as abdominal cramps, muscle weakness (Susheela and Das, 1988). Skeletal symptoms also include tingling and numbing of extremities and difficulty in breathing when bending forward (Bharati et al., 2005). Studies have also shown that malnutrition, deficiencies in micronutrients particularly Vitamin C and Vitamin D aggravate the fluoride toxicity (Susheela and Bhatnagar, 2002 a,b). Thus the toxic effects of fluoride could be successfully reversed by withdrawal of fluoride source and subsequent supplementation of Vitamin C and Calcium (Susheela and Bhatnagar, 2002a,b).

Many animal studies have reported renal damage even at lower levels of fluoride exposure over long period of time (Junco, 1972). Furthermore, a team of Chinese researchers reported that elevated ingestion of fluoride during childhood can cause kidney damage (Liu et al., 2005). According to their findings an obvious "dose-effect relationship" existed between the children's

water fluoride exposure (>2ppm) and the two markers of kidney damage (urinary NAG and gamma-GT activity). Moreover, the aetiology of various clinical disorders monitored in patients with renal failure has been attributed to aluminum intoxication (Haftenberger et al., 2001).

In Sri Lanka, an equatorial developing country with a population of about 20 million, consist of wet and dry zones. In the dry zone, dental fluorosis is highly prevalent and a population over 2 million are at risk (Dissanayake, 2005). A collaborative study conducted by National Water Supply and Drainage Board and WHO has mapped the distribution of fluoride ions in ground water of Sri Lanka (WHO,1985). Accordingly, the regions around Eppawala and Anuradhapura have been reported to have the highest fluoride concentrations in ground water. These, findings were upgraded later (Dissanayake, 2005). Most rural Sri Lankans live in harmony with their immediate geological environment, and only about 30% have cleaned pipe water with controlled mineral content. The rest generally use wells as their source of water. In some dug wells and most notably in deep boreholes the fluoride concentration in water is high ranging from 1.5 mg/l to 10 mg/l (Dissanayake, 2005). The sources of fluoride are the high-grade metamorphic rocks in the dry zone with abundance of fluoride bearing minerals such as mica, hornblende and fluorite (Dissanayake, 2005). Therefore, excess fluorides in ground water in some parts of the country pose a serious water quality issue (Darmagunawardhane and Herath, 1993).

It has been reported few decades ago that the prevalence rate of dental fluorosis, in the North central province is ranging from 55% to 77% in 7-20 year old school children in the North Central Province (Seneviratne et al., 1973: Seneviratne et al., 1974). Nevertheless, a recent study reported a prevalence rate as high as 89.8% among 15-year-school children in Anuradhapura (Tennakoon, 2004). Moreover, while the aetiology of chronic renal failure in Sri Lanka still remains unresolved, there are speculations on geo-environmental factors such as ingestion of excessive quantities of naturally found fluoride in the ground water which could harm the kidney, excessive use of fertilizers, insecticides, and weedicides, the use of utensils made out of low quality cheap Aluminum to store water and to prepare food: *the fluoride content found in the groundwater reacts with the Aluminum creating Toxic compounds (ALFx)* and entry of toxic element such as Cadmium via food chain. A study conducted in Madawacchchiya, Padaviya and Anuradhapura has revealed that there was about 25-fold enhancement of Aluminium dissolution when 1ppm fluoride was present in the medium (Herath et al., 2005). With emerging evidence for adverse health effects of long term ingestion of excessive fluorides, there is a growing need to investigate the issues, identify safe water sources and introduce cost effective, sustainable methods to prevent and control fluorosis.

No studies to date have assessed the overall effects of excessive ingestion of fluorides with an intervention. Therefore, the extent of the problem of fluorosis in Sri Lankan context is not known. Hence, the present study was undertaken to shed some light into existing knowledge gaps on the effects of excessive ingestion of fluorides in people living in endemic areas. Importantly the study also consisted of identifying safe water sources as well as introduction of a simple defluoridation method as a prevention and control measure which is sustainable.

II) Scientific scope of the project (overall and specific objectives)

Overall objective: To investigate the effects of excessive ingestion of fluorides in people living in endemic areas.

Specific objectives:

- To determine the prevalence and severity of fluorosis in people living in endemic areas.
- To investigate the relationship of nutritional status of people with the occurrence of fluorosis in endemic areas
- To introduce a simple de-fluoridation method for the people those who consume excess amounts of fluorides and assess the effectiveness of the method in order to relive the acute symptoms due to fluorosis.

III) Materials and methods (including statistical methods)

Study area: Thambuttegama MOH area was selected as the study area based on high prevalence of dental fluorosis and commendable dedication and enthusiasm of the PHC staff which was mandatory to successful conduct of the present study. To select the study area a field visit was made on 27th and 28th of May 2006.

Figure 3.1: Distribution of PHM Areas
MOH – Thambuththegama

Table3.1: Population Statistics- 2007
MOH – Thambuththegama

	P H M Area	Population
1	Thambuththegama	2114
2	Weheragala	2950
3	Musalpitiya	5210
4	Rajapaksagama	3548
5	Pahalagama	2998
6	Kongollewa	3814
7	Ariyagama	2709
8	Mudungoda	2760
9	Sudharshanagama	3153
10	Thelhitiyawa	3981
11	Nallachchiya	3600
12	Hurigaswewa	2515
13	Thammannapura	3605
	Total	**42957**

Study design: community-based, descriptive study which was conducted in two stages:

Stage 1- A survey to find out the status of fluorosis of people.

Stage 2- Introduction of a simple defluoridation method for the people who are suffering from acute symptoms of fluorosis and assessment of its effectiveness in relieving acute symptoms.

Stage 1

Study Sample: 400 Adolescents aged 12-15 years and 400 adults aged 35-44 years. These two age groups were selected for comparative purposes. However, the final sample consisted of 382 adolescents and 368 adults selected from 13 PHM areas.

Sample size: Estimated sample size was 800 subjects consisting of 400 in each group. This calculation was based on 55% prevalence of dental fluorosis in the area, tolerated error margin of 5% and 95% Confidence interval.

Selection of the sample: PI and a collaborator attended the MOH conference at Thambuttegama on 4th August 2006. PHMM were instructed to randomly select 30-35, 12-15 year old adolescents (those who were born from 29.08.1991 to 27.08.1994) and 30-35, 35-44-year-old-adults (those who were born between 27.08.1962 to 29.08.1971) distributed across the area without selecting two persons of same age group from the same household.

Examination criteria and methods

Following measurements were taken for the assessment of fluorosis status of the subjects.

- Status of dental fluorosis was assessed by using Dean's index (Dean, 1934) and TF index (Thylstrup and Fejerskov, 1978). These two indices are specific fluorosis indexes and used for assessing enamel defects due to chronic, accumulated ingestion of fluoride (Pereira and Moreira, 1999).

  Dean's index classifies individuals into 5 categories depending on the degree of enamel alteration, and which was achieved based on the identification of the two most severely affected teeth, giving ordinal numbers as the severity of enamel is increased.

The TF index is based on the biological aspects of dental fluorosis, classifying individuals into 9 categories characterizing the macroscopic degree of fluorosis in relation to histological aspects. Hence this index was selected because of its higher number of classifications which resulted in higher sensitivity to the variation in severity of dental fluorosis (Rozier, 2004). Due to comparative purposes, 9 scores of TF index were collapsed into three as normal (score=0), opacity only (scores= 1-4) and opacity & surface loss (scores=5-9). To explore associations 3 categories of TF index was used.

- Presence of acute symptoms due to early skeletal fluorosis: a check list of nine self-reported symptoms for past 6 months, were developed after an extensive literature (Bharati et al., 2005) and obtaining consensus from experts. Symptoms consisted of Tingling sensation of extremities, Joint pain, body ache, back ache, knee joint pain, difficulty in bending hands, difficulty in walking, abdominal cramps and difficulty in breathing when bending forwards. For comparative purposes these symptoms were categorized into three groups as no symptoms, up to 3 symptoms and > 3 symptoms.

- Status of skeletal fluorosis- this was assessed by capability of performing three physical tests namely: touching floor or big toes without bending knees, touching the chest with chin by bending head forwards and touching the back of the head with palms of backwardly flexed arms (Sushhela and Bhatnagar, 2002 a,b). Moreover, squatting position was assessed in a sub-sample of participants. Nevertheless, it was not considered for calculation of total number of physical tests.

- Nutritional status of people: This was assessed by using BMI calculated by measuring the weight and height by calibrated scales.
  BMI =Weight (Kg)/Height $(m)^2$
  According to BMI value individuals were categorized into three groups: Low=<18.5, Healthy =18.5-25, Overweight=25-30, Obese => 30

- Fluoride concentration of urine: Early morning spot samples of urine were collected into pre-labeled plastic bottles* on the respective days of data collection and analyzed for fluoride concentration by iron sensitive fluoride electrode. However, this was done among a sub-sample of participants (n=278). Distribution of urine collection bottles were given to the participants via PHMM. A leaflet was prepared explaining the study objectives and instructions on collection and handover of water and urine samples for fluoride analyses.

Calculation of fluoride intake

When assessing the safety of various levels of fluoride ingestion it is important to consider the fluoride intake from all potential sources. These sources might include fluoride ingestion from drinking water, food and beverages, oral care products and other environmental exposures (Mariñoetal., 2006). As urine is the main excretion route for ingested fluoride (Mariño et al., 2006), analysis of the fluoride concentration in urine is a useful way to estimate the overall fluoride intake of a population (Yadav and Lata, 2003).
As spot sample of urine was advocated for the present study due to feasibility and as recommended by Susheela and Bhatnagar,2002 a,b, following calculation was made to estimate daily minimum fluoride intake.

Minimum urine output (on average for a healthy individual)=1ml/Kg BW/Hr
Therefore, urine output per day =1 x Kg BW x 24
Fluoride intake, assuming 50% *(Ketley and Lennon, 2000)* of ingested is being excreted)=[urinecon/1000]KgBW x 24 x 2
Fluoride intake/KgBW ={[urinecon/1000] x KgBW x 24 x2}/KgBW
={[urinecon/1000] x 24 x2}
Grouping of individuals mg/KgBW
Up to0.07 (Burt, 1992) = Safe, 0.0701-0.2000=high, >0.2001=very high

- Fluoride concentration in drinking water: A sample of drinking water was collected and analyzed for fluoride concentration by Calorimetric method using SPANDS reagent. As it was repeatedly confirmed that tap water had safe levels of fluorides, tap water was excluded for analysis of fluoride levels. Water samples were also collected into pre-labeled plastic bottles*.
  * *Samples were collected in plastic containers and not on glass bottles as there is a possibility of fluoride in the sample reacting with silica in the glass resulting in unreliable data (Susheela and Bhatnagar, 2002a, b)*

Development of an interviewer administered questionnaire

An interviewer administered questionnaire was developed confirming to study objectives. First part of the questionnaire consisted of socio-demographic information and the second part consisted of a check list of acute symptoms of fluorosis. The third part consisted of physical tests to detect skeletal fluorosis and the fourth part included indices of dental fluorosis: Dean's index and TF index. Questionnaires were pre-tested and necessary modifications were made.

Pilot study: Examiner training and calibration
A pilot study including 30 adolescents aged 12-15 years and 30 adults aged 35 to 44 years was conducted in Maho on 22nd August 2006 in order to get familiarized with examination criteria. Examiner training and calibration was conducted on the same day.

Picture 1: Stage I of the study: Participants awaiting for their turn.

Picture 2: Clinical examination, and administering questionnaires to participants.

Picture 3: Administering questionnaires to participants.

Data Collection:

Data collection was conducted in two sessions namely (PHM areas- Thambuttegama, Weragala, Kongollagama, Pahathgama, Hurigaswewa, Mudungoda, Thelhiriyawa and Sudharshanagama) on 28th ,29th August 2006 and 25th ,26th September 2006 which included Nallachchiya, Konwewa, Areagama,Musalpitiya, Thammennapura and Kalawellawa. All clinical examinations were conducted by trained and calibrated examiners during day light. Water and urine samples were sent to the MOH office by transport vehicles where the fluoride analyses were done by the second investigator, who is an expert in the field.

Initially it was planned to conduct a house to house survey for data collection but it was modified due to practical and logistic reasons. Therefore, data collection was done at pre-arranged venues eg. Community centers, pre schools due to practical reasons and in one instance a school was visited for data collection among respective adolescent school children.

Stage 2:

This stage consisted of 3 components

Component 1

Rapid Assessment of Functional status of fluoride filters
Confirming to availability of funds 90 filters were purchased from Wayamba Polymers Co.Ltd at a unit cost of Rs.1850.00. A list was prepared on 100 potential recipients who consumed water from sources with fluoride levels >2mg/l as well as to be estimated to have intake of minimum daily intake of fluoride >0.2g/Kg/BW. Out of them 90 recipients were selected due to availability of filters. All the participants were informed on the levels of fluoride in their drinking water and some of them who consumed water sources as high as 8 mg/l were willingly replace their water sources with tap lines.

Selected participants who consumed excess amounts of fluoride in drinking water were given a scientifically proven defluoridation filter, relevant instructions and a practical demonstration in order to use it effectively. These filters were distributed among few recipients at a ceremony held on 17.12.2007 at the MOH office, Thambuttegama. Prior to distribution of filters a fresh sample was collected from each selected source of water and levels of fluoride was determined by colourimetric method using SPANDS reagent to assess the reliability of previous findings. The fluoride level estimation by this method is based on the reaction between fluoride and a red zirconium- dye lake that has been formed with SPANDS (Methods,1974:1998:Thomas and Chmberlain,1974). The loss of colour resulting from the reaction of the fluoride concentration in the given sample of water is expressed in ppm (mg/l). The upper detection limit for fluoride is 2.0 mg/l and if the sample reads at or above 2.0, a serial dilution is required to determine the actual concentration.

Picture 4: The status of skeletal fluorosis was assessed by capability of performing three physical tests. The picture shows a participant is performing physical test before Family Health Worker

Picture 5: Assessing the fluoride levels in spot samples of urine.

Picture 6: Assessing fluoride l samples of drinking water.

The rapid assessment of functional status of fluoride filters was done by 2 hour filtration of three samples of the same water source which had a fluoride content of 6.55 mg/l, using three sources of filtering media (newly produced bricks broken into pieces of 15-20 mm diameter

Component 2

Short term evaluation of effectiveness of fluoride filters among recipients

This was carried out after 6 months (July-August 2008) of distribution of filters by the Regional Dental Surgeon and Primary Health Care staff. This involved 63 out of original 90 recipients of fluoride filters. This was primarily due to provision of piped water to Nalachchiya PHM area with subsequent replacement of filter use by pipe-born water. Determination of levels of fluoride in water stored in filters by Colorimetric method was used for data collection for this evaluation.

Component 3

Long term evaluation of effectiveness of fluoride filters among recipients

This was conducted on 23rd & 24th February 2009 after 14 months of distribution of filters by the investigators and local staff comprising of the Regional Dental Surgeon and the Primary Health Care staff. However, due to feasibility and logistic constraints it was confined to 44 out of 64 recipients who were using filters during the time of short term evaluation. An interviewer administered questionnaire and determination of levels of fluoride in water stored in filters by Colorimetric method were used for data collection. The questionnaire consisted of 3 components: basic information about the household, inspection report and factors about use of fluoride filters which included reasons for utilization of filters, perceived problems in use and suggestions for improvement.

Operational Definitions used for the evaluation

Users of fluoride filters

Out of recipients, current users of fluoride filters at the time of evaluation

Non users/ Defaulters

Out of recipients, those who have given up use of fluoride filters at the time of evaluation

Effective Users

Of current users, the fluoride levels in a random sample of water in filters determined to be up to 0.8 ppm (mg/l).

This cut off point was selected based on recommended appropriate upper limit of F- in drinking water supplies for dry zone in Sri Lanka by Warnakulasuriya et al.,1992, the only documented recommendation for appropriate upper limit of fluoride in drinking water for Sri Lanka. Furthermore, this limit is in accordance with 1984 WHO guidelines which suggested that in areas with

Picture 7: The principle investigator addressing the gathering at ceremonial distribution of fluoride filters.

Picture 8: Fluoride filters.

Picture 9: Demonstration on use of fluoride filters to the recipients.

warm climate the optimal fluoride concentration in drinking water should remain below 1 mg/l (1ppm or part per million) (WHO, 1994). The WHO guideline values for fluoride in drinking water were reevaluated in 1996, without change and the issue is currently under further review.

Ineffective Users

Of current users, the fluoride levels in a random sample of water in filters determined to be up to > 0.8 ppm (mg/l)*.

* Water weighs 1 kg/l and dilute solutions in water are also very close to this, hence mg/l is essentially mg/kg and therefore numerically equal to ppm (since there are 1 million mg per kg).

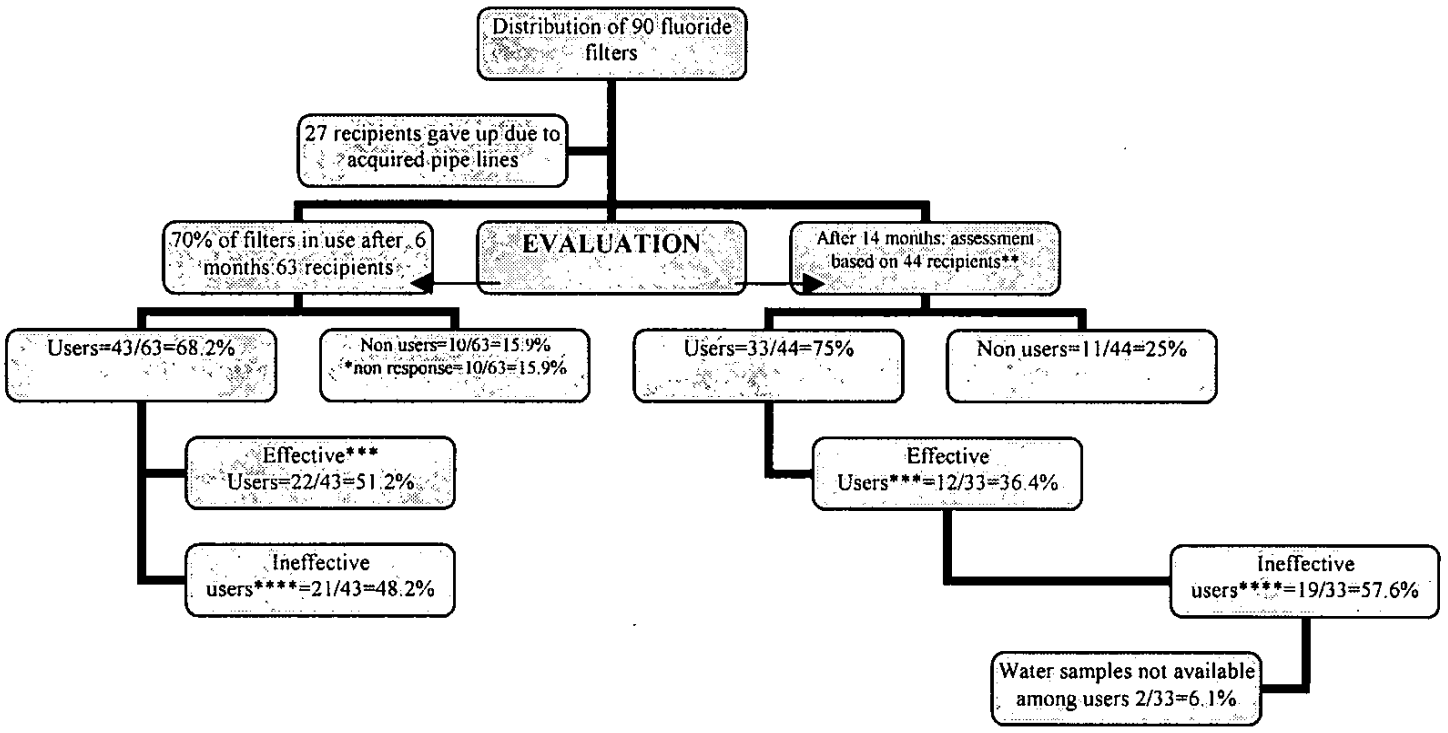

Figure 1: Schematic Representation of evaluation process.

** non response due to absence of owners of recipients in their homes at the time of assessment: this was conducted by PHC team lead by RDS-Anuradhapura*

*** This assessment was confined to 44 recipients due to feasibility and time constraints. It was conducted by a team lead by investigators including PHC team Thambuttegama. Hence, it is based on 69.8% of filters which were in use at the time of previous evaluation (6 months after distribution of filters)*

**** water fluoride levels <0.8 mg/l*

***** water fluoride levels >0.8 mg/l*

Ethical clearance

Ethical approval for the present study was obtained from the Ethical Review Committee, Faculty of Medicine, the University of Colombo. Approval to conduct the study was also obtained from the Provincial Health Authorities. Participation was voluntary and the informed Consent was obtained from all participants.

Data entry and analyses

Questionnaires were coded prior to data entry. SPSS-13 statistical software package was used for data entry and analysis. Descriptive statistics and the *Fisher's exact test/ chi square test* of association were used to evaluate the associations among predictive variables (nutritional status assessed by BMI, estimated daily minimum intake of fluoride) and outcome variables (occurrence of dental fluorosis, occurrence of skeletal fluorosis assessed by a check list of self-reported symptoms and performance of three physical tests). A significance level of 5% ($p<0.05$) was pre-determined. Fisher's exact test was used to detect the associations in all instances except one as the expected frequencies in cells of cross tabulations were less than 5.

IV) Results/outputs

Overall response rate was as high as 93.7%. Results are illustrated according to objectives.

A. Results by specific objective 1:
To determine the prevalence and severity of fluorosis in people living in endemic areas.

A.1. Dental Fluorosis

Table: A.1.1. Distribution of the sample by Deans Index

			Age group (%)		Total
			Children	Adults	
Deans Index	0	Healthy	43 (11.3)	168 (46.5)	211 (28.5)
	1	Questionable	35 (9.3)	25 (7.0)	60 (8.1)
	2	Very mild	59 (15.6)	32 (8.9)	91(12.3)
	3	Mild	49 (12.9)	28 (7.8)	77 (10.4)
	4	Moderate	99 (26.1)	48 (13.1)	147 (19.9)
	5	Severe	94 (24.8)	60 (16.7)	154 (20.8)
Total			379 (100.0)	361 (100.0)	740 (100.0)

According to Dean's index of dental fluorosis (Table A.1.1), 11.3% of children and 46.5% of adults were healthy. Another 9.3% of children and 7% of adults had *questionable* dental fluorosis. Among children the majority (26.1%) were classified into *moderate* dental fluorosis. Moreover, a one fourth of them (24.8%) had severe form of dental fluorosis according to Dean's index. In contrast, among adults only 16.7% and 13.1% were affected by *severe* and *moderate* levels of dental fluorosis according to same index.

Table: A.1.2. Distribution of the sample by TF Index

		Age group (%)		Total
		Adolescents	Adults	
TF Index	0	54 (14.3)	183 (50.7)	237 (32.0)
	1	48 (12.7)	26 (7.2)	74 (10.0)
	2	52 (13.7)	22 (6.1)	74 (10.0)
	3	71 (18.7)	50(13.6)	121 (16.4)
	4	66 (17.4)	39 (10.9)	105 (14.2)
	5	65 (17.2)	26 (7.2)	91 (12.3)
	6	16 (4.2)	11 (3.1)	27 (3.6)
	7	6 (1.6)	2 (0.6)	8 (1.1)
	8	0 (0.0)	2 (0.6)	2 (0.3)
	9	1 (0.3)	0 (0.0)	1 (0.1)
Total		379 (100.0)	361 (100.0)	740 (100.0)

According to Table A.1.2, only 14.3% of children and 50.7% of adults were healthy by TF index. For clarity and comparative purposes the 0-9 categories of TF index are summarized into three groups as shown in table A.1.2.

Table: A.1.2.1 Distribution of the sample by the summarized version of TF index

TF index	Age group		Total
	Adolescents	Adults	
Normal (0)	54 (14.3%)	183 (50.7%)	237(32.0%)
Opacity only (1-4)	237(62.5%)	137(37.9%)	374 (50.5%)
Opacity & surface loss (5-9)	88 (23.2%)	41 (11.4%)	129 (17.5%)
Total	379 (100.0%)	361 (100.0%)	740 (100.0%)

As classified by the summarized version of TF index, shown in Table A.1.2.1 14.3% of children and 50.7% of adults had normal teeth. However, the majority of children (62.5%) and 37.9% of adults had opacity only (TF scores1-4). Moreover, a considerable 23.2% of children and 11.4% of adults had severe form of dental fluorosis consisted of both opacity and surface loss. In overall, prevalence and severity of dental fluorosis was more among children compared to adults in the Thambuttegama MOH area.

Table: A.1.2.2 Community Fluorosis Index (CFI)

Age Group	*CFI*
Children	2.24
Adults	1.34

According to Table A.1.2.2, CFI for children is 2.24 and for adults 1.34. Therefore, CFI is higher for children than for adults in Thambuttegama MOH area.

Table: A.1.2.3a Distribution of the sample by Self-reported awareness of having dental fluorosis

Awareness	Age group		Total
	Children	Adults	
Aware	173 (45.3%)	157 (24.8%)	330(44.2%)
Unaware	207(54.5%)	210 (57.2%)	417 (55.8%)
Total	380(100.0%)	367 (100.0%)	747 (100.0%)

Table: A.1.2.3b Distribution of the sample by Self-reported impact of having dental fluorosis

Awareness	Age group		Total
	Children	Adults	
Having impact	169 (44.5%)	126 (34.3%)	295(44.2%)
No impact	211(55.5%)	241 (65.7%)	452 (55.8%)
Total	380(100.0%)	367 (100.0%)	747 (100.0%)

Among children and adults the majority 54.5% and 55.8% respectively reported to be unaware of having dental fluorosis (Table A.1.2.3a). Moreover, 55.5% of children and 65.7% of adults respectively reported that they do not have any impact to daily activities due to fluorosis status (Table A.1.2.3b).

A.2. Skeletal Fluorosis

Table: A.2.1 Distribution of the sample by self-reported Symptoms (multiple responses were allowed)

Symptom	Children		Adults	
	Number: responded	Presence of symptom (%)	Number responded	Presence of symptom (%)
Tingling	381	33 (8.7)	364	153 (42.0)
Joint pain	382	32 (8.4)	366	179 (48.9)
Body ache	381	29 (7.6)	366	148 (40.4)
Back ache	381	41 (10.8)	366	220 (60.1)
Knee joint pain	381	37 (9.7)	366	154 (42.1)
Difficulty in bending hands	382	12 (3.1)	365	88 (24.1)
Difficulty in walking	382	10 (2.6)	363	79 (21.8)
Abdominal cramps	123	21 (17.1)	103	18 (17.5)
Difficulty in breathing bending forwards	115	2 (1.2)	104	14 (13.5)

As illustrated by Table A.2.1, *abdominal-cramp* was the highest reported symptom by children (17.1%) followed by back ache (10.8%) and knee-joint pain (9.7%). Among adults, the majority (60.1%) reported back ache, followed by joint pain (48.9%), knee-joint pain (42.1%) and tingling (42.0%) respectively. Backache, knee-joint pain and tingling were commonly reported by both children and adults. In general adult participants reported higher number of symptoms compared to adolescents in this study.

However, for clarity and comparability the symptoms were summarized into three groups as illustrated in Table A.2.1.1.

Table: A.2.1.1 Distribution of the sample by a summarized version of self-reported Symptoms

Symptoms	Age group		Total
	Children	Adults	
No symptoms	291(76.2)	68 (18.5)	359(47.8)
Upto 3 symptoms	77 (20.2)	153(41.6)	230 (30.7)
Four or more symptoms	14 (3.6)	147 (39.9)	161 (21.5)
	382 (100.0)	368 (100.0)	750 (100.0)

As shown in Table A.2.1.1 the overwhelming majority of children (76.2%) and almost half of adults (48.0%) reported no symptoms. Another 20.2% of children and 41.6% of adults reported upto three symptoms. The percentage of adults who reported >3 symptoms was 39.9% and higher compared to 3.4% of children.

Table: A.2.2. Distribution of the sample by inability to perform physical tests: exercise (multiple responses were allowed)

Exercise	Children		Adults	
	Number: tested	Unable to perform	Number tested	Unable to perform
Bending forward	379	28 (4.5%)	356	27 (7.6%)
Bending head	379	39 (1.6%)	360	39 (10.8%)
Folding hands	379	5(1.3%)	360	5 (1.4%)
Squatting *	123	1 (0.8%)	103	10 (9.7%)

*Squatting was tested in a sub-sample

As shown in Table A.2.2, the percentages of both children and adults whom were unable to perform three physical tests were discernibly low. Nevertheless, among children the majority 4.5% could not perform *"bending forward"* while among adults "bending head" emerged as the main exercise which could not be performed (10.8%). However, for clarity and interpretability the results are further presented in Table A.2.2.1

Table: A.2.2.1. Distribution of the sample by Exercise grouping

Exercise	Age group		Total
	Children	Adults	
All 3 failed**	3 (0.8)	3 (0.8)	6 (0.8)
2 failed	1 (0.3)	7 (1.9)	8 (1.1)
1 failed	16 (4.2)	51 (14.2)	67 (9.1)
All possible	359 (94.7)	299 (83.1)	658 (89.0)
	379 (100.0)	360 (100.0)	739 (100.0)

**As Squatting was tested in a sub-sample, it was not considered for calculation of total number of exercises.

As described in Table A.2.2.1 the overwhelming majority of children (94.7%) and 83.7% of adults were able to perform all three physical tests. A negligible 0.8% of both adults and children were unable to perform al 3 tests.

B. Results of specific objective 2: To investigate the relationship of nutritional status of people with the occurrence of fluorosis in endemic areas

Nutritional status was measured by using BMI index
BMI=weight (Kg)/Height $(m)^2$

BMI grouping
< 18.5 = Low, 18.5 – 25 = Healthy, 25-30 = Overweight, >30 = Obese

B.1. Dental Fluorosis (TF) vs Nutrition status (BMI)

Table: B.1.1. Children

TF grouping	BMI				Total (%)
	Low	Normal	High Overweight	Very high obese	
Normal	38 (13.8%)	13 (14.1%)	2 (25.0%)	1 (50.0%)	54 (14.3%)
Opacity only	174 (63.0%)	56 (60.9%)	6 (75.0%)	1 (50.0%)	237 (62.7%)
Opacity & surface loss	64 (23.2%)	23 (25.0%)	0 (0.0%)	0 (0.0%)	87 (23.0%)
Total	276 (100.0)	93 (100.0%)	9 (100.0%)	2 (100.0%)	380(100.0%)

Fisher's exact Test = 5.334 df=6 P=0.450
5 cells (41.7%) have expected count less than 5. The minimum expected count is .29.

The occurrence of dental fluorosis as assessed by TF index was more among children who had low BMI compared to those with normal or high BMI. However, these differences were not statistically significant (Table B.1.1).

Table: B.1.2. Adults

TF grouping	BMI				Total (%)
	Low	Normal	High Overweight	Very high Obese	
Normal	30 (63.8%)	94 (51.4%)	39 (41.9%)	16 (47.1%)	179 (50.1%)
Opacity only	14 (29.8%)	63 (34.4%)	45 (48.4%)	15 (44.1%)	137 (38.4%)
Opacity & surface loss	3 (6.4%)	26 (14.2%)	9 (9.7%)	3 (8.8%)	41 (11.5%)
Total	47 (100.0%)	183 (100.0%)	93 (100.0%)	34 (100.0%)	357 (100.0%)

Fisher's Exact Test = 9.599 df=6 P=0.137
1 cells (8.3%) have expected count less than 5. The minimum expected count is 3.90.

As revealed by Table B.1.2 there was no statistically significant relationship in the occurrence of dental fluorosis and nutritional status assessed by BMI among adults.

B.2. Skeletal Fluorosis (symptoms) vs Nutritional status (BMI)

Table: B.2.1. Children

Symptoms	BMI				Total
	Low	Normal	High Overweight	Very high Obese	
No symptoms	210 (75.3%)	71 (77.2%)	8 (100.0%)	1 (50.0%)	290 (76.1%)
Up to 3 symptoms	58 (20.8%)	19 (20.6%)	0 (0.0%)	0 (0.0%)	77 (20.2%)
4-7 symptoms	11 (3.9%)	2 (2.2%)	0 (0.0%)	1 (50.0%)	14 (3.7%)
Total	279 (100.0%)	92 (100.0%)	8 (100.0%)	2 (100.0%)	381 (100.0%)

Fisher's Exact Test = 8.092 df=6 P=0.211
6 cells (50.0%) have expected count less than 5. The minimum expected count is .07.

According to Table B.2.1 there was no statistically significant relationship between nutritional status assessed by BMI and self-reported symptoms of early skeletal fluorosis among children.

Table: B.2.2. Adults

Symptoms	BMI				Total
	Low	Normal	High Overweight	Very high Obese	
No symptoms	12 (25.5%)	32 (17.2%)	14 (14.7%)	7 (20.6%)	65 (18.0%)
Up to 3 symptoms	18(38.3%)	79 (42.5%)	41 (43.1%)	13 (38.2%)	151 (41.7%)
4-7 symptoms	17 (36.2%)	75 (40.3%)	40 (42.1%)	14 (41.2%)	146 (40.3%)
Total	47 (100.0%)	186 (100.0%)	95 (100.0%)	34 (100.0%)	362 (100.0%)

Pearson Chi square Test = 2.826 df=6 P=0.834
0 cells (50.0%) have expected count less than 5. The minimum expected count is 6.10.

According to Table B.2.2 there was no statistically significant relationship between nutritional status assessed by BMI and self-reported symptoms of early skeletal fluorosis among adults.

B.3 Skeletal Fluorosis (Exercise) vs Nutritional status (BMI)

Table: B.3.1. Children

Exercise	BMI				Total
	Low	Normal	High Overweight	Very high Obese	
All 3 failed	3 (1.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (0.8%)
2 failed	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.3%)
1 failed	12 (4.3%)	4 (4.4%)	0 (0.0%)	0 (0.0%)	16 (4.2%)
All possible	261 (94.2%)	87 (95.6%)	8 (100.0%)	2 (100.0%)	358 (94.7%)
Total	277 (100.0%)	91 (100.0%)	8 (100.0%)	2 (100.0%)	378 (100.0%)

Fisher's Exact Test= 10.826 df=9 P=0.992
12 cells (75.0%) have expected count less than 5. The minimum expected count is .01.

Table: B.3.2. Adults

Exercise	BMI				Total
	Low	Normal	High Overweight	Very high Obese	
All 3 failed	0 (0.0%)	2 (1.1%)	0 (0.0%)	1 (3.0%)	3 (0.8%)
2 failed	3 (6.4%)	1 (0.5%)	3 (3.2%)	0 (0.0%)	7 (2.0%)
1 failed	6 (12.8%)	30 (16.4%)	11 (11.7%)	3 (8.8%)	50 (14.0%)
All possible	38 (80.9%)	150 (82.0%)	80 (85.1%)	30 (98.2%)	298 (83.2%)
Total	47 (100.0%)	183 (100.0%)	94 (100.0%)	34 (100.0%)	358 (100.0%)

Fisher's Exact Test= 11.152 df=9 P=0.171
9 cells (56.3%) have expected count less than 5. The minimum expected count is .28.

There were no statistically significant relationships between skeletal fluorosis assessed by performance of three physical tests and BMI both among children and adults (Tables B.3.1 and B.3.2).

C. Calculation of fluoride intake

Minimum Urine output (on average for a healthy individual)= 1ml/kgBW/Hr
Therefore urine output per day = 1 x KgBW x 24
Fluoride excretion /day = [urinecon/1000] x KgBW x 24
Fluoride intake (assuming 50% of ingested is excreted) = [urinecon/1000] x KgBW x 24 x 2
Fluoride intake /KgBW = {[urinecon/1000] x KgBW x 24 x 2}/KgBW
= {[urinecon/1000] x 24 x 2}
Grouping mg/kgBW
- upto 0.07 mg/KgBW=safe, >0.07-0.2 =high, >0.2= very high

Table: C.a Descriptive statistics related to urinary and water fluoride levels among children

	number	*minimum*	*maximum*	*Mean (SD)*	*Standard error*	*variance*	*skewness*
Water fl mg/l	300	0.02	8.63	1.195 (1.04)	0.06	1.09	0.14-check
Urine fl mg/l	145	0.28	22.8	2.24 (2.71)	0.23	7.37	0.20

Table: C.b Descriptive statistics related to urinary and water fluoride levels among adults

	number	*minimum*	*maximum*	*Mean (SD)*	*Standard error*	*variance*	*skewness*
Water fl mg/l	306	0.02	5.68	1.214 (1.03)	0.06	1.06	1.57
Urine fl mg/l	304	0.17	8.17	1.86 (1.29)	0.07	1.66	2.375

As revealed by the findings the mean fluoride levels were higher 2.24 (2.71) among children than among adults 1.86 (1.29). (Tables C.a and C.b)

Table: C.c The correlation between water fluoride levels and urinary fluoride levels

	Spearman correlation coefficient
Children	0.57 (p=0.01)
Adults	0.18 (p=0.01)

According to the findings there is a moderate correlation among water and urinary fluoride levels among children while there is a low correlation among adults. However, these correlations are statistically significant (TableC.c).

Table: C.1.1. Adolescents

TF index	*Minimum Fluoride Intake mg/Kg BW/Day*			*Total*
	Safe:upto 0.07	*High: >0.07-0.2*	*Very High: >0.2*	
Normal	15 (20.6%)	10 (16.1%)	0 (0.0%)	25 (17.4%)
Opacity only	48 (65.7%)	35 (56.5%)	5 (55.6%)	88 (61.1%)
Opacity & surface loss	10 (13.7%)	17 (27.4%)	4 (44.4%)	31 (21.5%)
Total	73 (100.0%)	62 (100.0%)	9 (100.0%)	144 (100.0%)

Fisher's Exact Test= 7.416 df=4 p=0.095
2 cells (22.2%) have expected count less than 5. The minimum expected count is 1.56.

As shown in Table C.1.1, severity of dental fluorosis high among children with higher daily minimum fluoride intake. However, these differences were not statistically significant.

Table: C.1.2. Adults

TF index	*Minimum Fluoride Intake mg/Kg BW/Day*			*Total*
	Safe:upto 0.07	*High: >0.07-0.2*	*Very High: >0.2*	
Normal	24 (41.4%)	26 (45.6%)	5 (31.2%)	55 (42.0%)
Opacity only	25 (43.1%)	20 (35.1%)	9 (56.3%)	54 (41.2%)
Opacity & surface loss	9 (15.5%)	11 (19.3%)	2 (12.5%)	22 (16.8%)
Total	58 (100.0%)	57 (100.0%)	16 (100.0%)	131 (100.0%)

Fisher's Exact Test= 2.398 df=4 p=0.675
1 cell (11.1%) have expected count less than 5. The minimum expected count is 2.69.

There was no statistically significant relationship between occurrence of dental fluorosis and minimum daily fluoride intake among adults.

C.2. Fluoride intake vs Skeletal fluorosis – Symptoms

Table: C.2.1. Children

Symptoms	*Minimum Fluoride Intake mg/Kg BW/Day*			*Total*
	Safe:upto 0.07	*High: >0.07-0.2*	*Very High: >0.2*	
No symptoms	61 (83.6%)	50 (79.4%)	8 (88.9%)	119 (82.1%)
Upto 3 symptoms	10 (13.7%)	10 (15.9%)	0 (0.0%)	20 (13.8%)
>3 symptoms	2 (2.7%)	3 (4.8%)	1 (11.1%)	6 (4.1%)
Total	73 (100.0%)	63 (100.0%)	9 (100.0%)	145 (100.0%)

Fisher's Exact Test= 3.127 df=4 p=0.502
4 cells (44.4%) have expected count less than 5. The minimum expected count is 0.37.

Children whose daily minimum fluoride intake was higher reported more symptoms than those who consumed safe levels of fluoride. However, these differences were not statistically significant (Table-C.2.1).

Table: C.2.2. Adults

Symptoms	*Minimum Fluoride Intake mg/Kg BW/Day*			*Total*
	Safe:upto 0.07	*High: >0.07-0.2*	*Very High: >0.2*	
No symptoms	13 (22.0%)	16 (27.6%)	0 (0.0%)	29 (21.8%)
Upto 3 symptoms	25 (42.4%)	22 (37.9%)	11 (68.8%)	58 (43.6%)
>3 symptoms	21 (35.4%)	20 (34.5%)	5 (31.2%)	46 (34.6%)
Total	59 (100.0%)	58 (100.0%)	16 (100.0%)	133 (100.0%)

Fisher's Exact Test= 7.753 df=4 p=0.097
1 cell (11.1%) have expected count less than 5. The minimum expected count is 3.49

There was no statistically significant relationship between severity of self-reported symptoms and minimum daily fluoride intake among adults.

C.3. Fluoride intake vs Skeletal fluorosis – Exercises

Table: C.3.1. Children

Exercises	*Minimum Fluoride Intake mg/Kg BW/Day*			*Total*
	Safe:upto 0.07	*High: >0.07-0.2*	*Very High: >0.2*	
All 3 failed	1 (1.4%)	1 (1.6%)	0 (0.0%)	2 (1.4%)
Two failed	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (2.1%)
One failed	2(2.8%)	1(1.6%)	0 (0.0%)	3 (0.0%)
All possible	69(95.8%)	60 (96.8%)	9(100.0%)	138(96.5%)
Total	72 (100.0%)	62 (100.0%)	9 (100.0%)	143(100.0%)

Fisher's Exact Test= 1.563 df=4 p=1.000
6 cells (66.7%) have expected count less than 5. The minimum expected count is 0.13.

According to Table C.3.1, there is no statistically significant relationship between skeletal fluorosis assessed by performance of three physical tests and daily minimum fluoride intake among children.

Table: C.3.2. Adults

Exercises	*Minimum Fluoride Intake mg/Kg BW/Day*		*Total*
	Safe:upto 0.07	*High: >0.07-0.2*	*Very High: >0.2*	
All 3 failed	1 (1.9%)	0 (0.0%)	0 (0.0%)	1 (0.8%)
Two failed	2 (3.8%)	2 (3.5%)	0 (0.0%)	4 (3.2%)
One failed	6 (11.3%)	2 (3.5%)	0 (0.0%)	8 (6.3%)
All possible	44 (83.0)	53 (93.0)	16 (100.0%)	113(89.7%)
Total	53 (100.0%)	57(100.0%)	16 (100.0%)	126(100.0%)

Fisher's Exact Test= 5.485 df=4 p=0.474
9 cells (75.0%) have expected count less than 5. The minimum expected count is 0.13.

There was no statistically significant relationship between skeletal fluorosis assessed by performance of three physical tests and daily minimum intake of fluorides among adults (Table C.3.2).

Results of specific objective 3: To introduce a simple defluoridation method for the people those who consume excess amounts of fluorides and assess the effectiveness of the method in order to relive the acute symptoms due to fluorosis.

Table D1: Rapid assessment of functional status of fluoride filters

Inlet mg/l	*Outlet mg/l*
6.55	1.95
6.55	0.59
6.55	1.78

As revealed by the findings, 2 hour filtration of the same source of water containing 6.55 mg/l resulted in different levels of fluoride based on the source of the filtering medium. Overall, fluoride filters deemed effective as a simple defluoridation method (Table D 1).

Table D2: fluoride levels in fluoride filters among recipients at 6 months and 14 month follow up periods

Name of the recipient	*PHM Area*	*Initial Fl level mg/l*	*Fl level after 6 months mg/l*	*Fl level after 14 months mg/l*	*Status*
1.Nirosha Rathnayake	Gurugama	2.26	0.69	0.72	in use
2.W.W.Jayasinghe	Gurugama	2.26	0.7	0.71	in use
3.GHM Chandralatha	Gurugama	2.26	0		not in use
4.GMG Heenbanda	Gurugama	2.26	0.16		not assessed
5.Gunaratne Menike	Gurugama	2.26	not in use	0.94	in use
6.KG Ranbanda	Gurugama	2.26	0.85	1.2	in use
7.AG HeenBanda	Gurugama	2.26	0.34	0.72	in use
8.L.Gunetunga	Solema	2.92	0.39	2.11	in use
9.Dilanee Wijesinghe	Solema	2.92	0.71	>2.2	in use
10.L.Sudhatie	Solema	2.92	0.75	>2.2	in use
11.AKPremawathie	Solema	2.92	2.2	>2.2	in use
12.Amila Srikantha	Solema	2.92	2.2	not assessed	
13.G.Piyasena	Solema	2.92	1.25	1.82	in use
14.K.Amarasena	Solema	2.92	not in use		
15.P.Gunasekera	Solema	2.92	0		
16.K.Asoka	Solema	2.92	2.2		not assessed
17.Amandika	Pahalagama	3.22	not in use		not in use
18.Ramya Sandaseeli	Pahalagama	3.22	owner not at home		
19.Kamala Kumari	Pahalagama	3.22	0.69	0.36	in use
20.Damayanthi Rathnayake	Pahalagama	3.1	0.85		
21.Athulasiri Bandara	Kongollewa	4.28	0.65		not in use
22.WA Wijearatne	Kongollewa	4.28	-	1.46	in use
23.RAM Ranbanda	Kongollewa	4.28	-		
24.Senarath Bandara	Kongollewa	4.28	0.11	0.19	in use
25.Anuala Kumari	Kongollewa	4.28	0	0.35	in use
26.Priyanka Kumari	Pothiyagama	4.18	1.07		
27.AG Ramyalatha	Kongollawa	2.86	0.69	0.96	in use
28.WM Ranbanda	Kongollagama	4.4	0.19		not in use
29.WM Kumarihamy	Kongollagama	4.4	0.41	0.18	in use
30.RM Ranbanda	Kongollagama	4.4	0.34	0.28	in use
31.Karunaratna Banda	Hurigaswewa	>2.2	not in use		
32.PB Wannihamy	Hurigaswewa	>2.2	2.2		not in use
33.Renuka Damyanthi	Hurigaswewa	>2.2	2.2	>2.2	in use
34.K.Samarakoon	Hurigaswewa	>2.2	1.19	>2.2	in use
35.DM Swarnalatha	Hurigaswewa	3.26	1.95	0.98	in use
36.MWD Kumarasekera	Hurigasweva	2.6	0	0.84	in use
37.Susila Jayalath	Hurigasweva	2.2	not in use		

Table D2: fluoride levels in fluoride filters among recipients at 6 months and 14 month follow up periods

Contd...

Name of the recipient	PHM Area	Initial Fl level mg/l	Fl level after 6 months mg/l	Fl level after 14 months mg/l	Status
38.SM Kanthilatha	Eriyagama	4.2	0	0.32	in use
39.Manoj Sanjith	Eriyagama	4.2	2.16	>2.2	in use
40.WM Seetha Kumari	Eriyagama	4.2	0.71		
41.DMK Gnasinghe	Eriyagama	3.9	2.2	1.9	in use
42. Umanda Rasikani	Eriyagama	3.8	2.2		
43.Kamalawathie	Eriyagama	3.8	-		not in use
44.Sriyalatha	Eriyagama	3.8	2.2		not in use
45.Yasomanike	Eriyagama	3.8	2.2		inadequate details
46.Mahesh Thilanka	Eriyagama	2.82	0.82	0.71	in use
48. Sanduni Nishadika	Eriyagama	2.8	owner not at home		not in use
49.Premalatha Jayakody	Tammennapura	2.18	1.86		
50.Indranee Jayakody	Tammennapura	2.18	1.98		
51.DPA Sriyalatha	Tammennapura	2.18	2.2		
52.Thilini Tharaka	Weheragala	3.86	2.2		
53.Deepani Dhammika	Pahalagama	3.32	not in use		not in use
54.Ruwani Maheshika	Pahalagama	2.92	not in use:new tap line		
55.Nandani Hemalatha	Solema	2.92	nin use:bad taste		not in use
56.Irangani	Solema	2.92	not in use filter has broken		
57.Iresha	Solema	2.92	2.13		
58.JM Swarnalatha	Hurigaswewa	3.26	1.4		not in use
59.Kamani Thanuja	Kongollagama	2.2	owner not at home		
60.Kanthi Ranathunga	Kongollagama		owner not at home		
61.Shiromi Hemamala	Kongollagama		owner not at home		
62.Ganga Kumari	Kongollagama		owner not at home		
63.WM Rohini Gunaratnemenike	Kongollagama	2.5	not in use		
64.B Sirisena				2.11	in use
65.Vineetha Sanjeewani	Pahalagama			1.87	in use
66.MR Ranbanda				0.56	in use
67.Ramya	Kongollagama			>2.2	in use
68.Premasiri	Solama				not in use

As shown in Table D.2, fluoride concentration of drinking sources of water was ranging from 4.40 mg/l to 2.16 mg/l among the selected recipients of fluoride filters.

Table D3: Distribution of the filter recipients by effective and non-effective users

CATEGORY	*EVALUATION*	
	After 6 months	After 14 months
Users n (%)	43 (68.2%)	33 (75.0%)*
Effective users	*22 (51.2%)*	*12 (36.4%)*
Ineffective users	*11 (48.8%)*	*19 (57.6%)*
		2(6.1%)-no water samples were available
Non users n (%)	10 (15.9%)	11 (25.0%)
Non response n (%)	10 (15.9%)	
Total	63 (100.0%)	44 (100.0%)

* could be an over-estimation as the evaluation based on only 44 out of 63 filter users

Of the 90 recipients of the filters 27 gave up the use of filters as they were supplied with pipe borne water supply. Therefore, only 63 users were involved in the first evaluation that was conducted six months after the distribution.

V) Discussion

Although manifestations of excessive ingestion of fluorides on mineralized tissues: teeth and bone are well-known, the non-skeletal entity of fluorosis, affecting soft tissues and organs of the body, is relatively a new condition (Susheela and Bhatnagar,2002a,b). It is now an established fact that fluoride ingestion over a period of time can affect the structure and functions of cells, tissues, organs and symptoms thus giving rise to a myriad of manifestations such as joint aches and pains, non-ulcer dyspepsia, polyurea and polydipsia, muscle weakness, fatigue, anaemia and fertility problems (Susheela and Bhatnagar,2002a,b). Importantly, fluorosis has no treatment but could be prevented and controlled through appropriate interventions and early diagnosis. Therefore, in the light of emerging evidence and its' importance in Sri Lankan context, present study was designed.

Present community based study denotes one of the first attempts to assess the effects of excessive intake of fluorides and its association with nutritional status in terms of dental and skeletal fluorosis in people living in an endemic area: Thambuttegama in Sri Lanka. High response rate (93.7%) of the study could be considered as an important strength. Nevertheless, comparability of present findings with similar studies becomes difficult due to variations in methodological aspects. Moreover, there are no comparable comprehensive studies conducted in Sri Lanka.

Another strength of the study was its phased implementation and multiple components of data collection which involved a self-administered questionnaire, check list of self-reported symptoms, performance of three physical tests, measuring weight and height, assessment of dental fluorosis by two indicators

(Dean's index) and TF index, and assessment of fluoride concentrations in drinking source of water and a early morning spot sample of urine. However, urine analysis was conducted on a subsample (278 out of 750) due to practical and logistic reasons. Moreover, one of the important study objectives aimed for the benefit of the community was to introduce a simple, cost-effective defluoridation method to those who consumed excessive levels of fluorides in drinking water sources. This was further justified by the fact that the overwhelming majority (83.2%) were using wells as their source of drinking water mostly with high fluoride levels. For successful implementation, sustainability, monitoring and evaluation of such a method requires dedication of all stakeholders with maximum community participation. Selection of Thambuttegama MOH area was governed by those factors in spite of primarily being a settlement area.

Socio-demographic information

Among children and adults the majority of the sample consisted of females. Among 12-15-year-old children 54.7% consisted of females and among 35-44 year-old adults 67.9% were females.

Discussion for specific objective 1: To determine the prevalence and severity of fluorosis in people living in endemic areas.

Prevalence and severity of dental fluorosis

Fluoride at optimal levels is considered as important resource for the control of dental caries. However, in high levels there are visible changes in dental structure, mainly in enamel thus resulting in dental fluorosis (Mariño et al.,2006). It is also important to emphasize that dental fluorosis is expected to occur only in case of excessive and prolonged fluoride ingestion during the period of dental development i.e.amelogenesis (Rozier, 1994). Several epidemiological indices have been used to describe the clinical appearance of dental fluorosis. In the present study, Deans Index (Dean, 1942) and Thylstruf and Ferjeskov Index-TF index have been used (Thylstruf and Fejerskov 1978; Ferjeskov et al., 1988). Dean's index is still in common use as recommended by WHO (WHO, 1987) while TF index has been recommended by contemporary researchers for field studies because of better defined criteria (Rosier, 1994).

As revealed by the findings of the present study, prevalence and severity of dental fluorosis is very high among 12-15 year old children as well as considerably high among 35-44 years-old-adults in Thambuttegama area. Accordingly 88.7% and 85.8% of the children had dental fluorosis according to Dean's index and TF index respectively. Moreover, among adults 53.5% and 49.3% were categorized as having dental fluorosis according those two indices respectively. According to the severity, by Dean's index 24.8% of children and 16.7% of adults had severe form of fluorosis as assessed by Dean's index. In the summarized version of TF index, 62.5% of children and 38.1% of adults had opacities while only 23.2% of children and 11.4% of adults had opacities and surface loss.

As illustrated by the results, the prevalence rate of dental fluorosis both among children and adults were not the same by two indices. Nevertheless, there was significant, excellent correlation between two indices (Spearman correlation coefficient =0.934: p=0.01). These findings were in agreement with similar studies (Pereira and Moreira, 1999). In their study among 12-14 year old school children in three cities of the State of São Paulo the prevalence of dental fluorosis was 32.7% and 33.3% by Dean's index and TF index separately. However, in the present study more cases have been classified as healthy by TF index compared with Dean's index. This could be attributed to different diagnostic criteria in two indices and inter examiner variability. Besides, as the TF index ranges from 0 to 9, the score 1 denotes thin, opaque white lines on the enamel, which can only be clearly observed when the tooth surface is clean and dry (Thylstruf and Fejesrskov, 1978). Under survey conditions of this nature in which natural day light is used and tooth surfaces are not air dried, it is plausible to misclassify some of the score 1 cases as score 0 (healthy).

Furthermore, the prevalence rate was comparable to recent studies conducted among school children in Sri Lanka. For example, prevalence of dental fluorosis as assessed by the Dean's index in a representative sample of 15-year-old school children in Anuradhapura was 89.8% according to Dean's Index (Tennakoon, 2004) while it was 88.7 % for the 12-15 year old school children in the present study. There were no comparative studies to compare the prevalence of dental fluorosis for adults. An important cause for concern as revealed by recent studies was the discernible increase in prevalence of dental fluorosis among children in the North Central Province. For example, studies conducted in 1970s reported prevalence of dental fluorosis was 55% to 77% in 7-20 year old school children in the North Central Province (Senevirathne et al., 1973:1974). This highlights the importance of conducting further research and cost-effective and sustainable remedial measures.

In the present study all the children were lifetime residents of the Thambuttegama area but some of the adults were settlers but it was not possible to exclude them as Thambuttegama was primarily a settlement area. Hence, this could have underestimated the prevalence and severity of dental fluorosis among adults.

Moreover, according to the Community Fluorosis Index (Dean, 1942):CFI, defined as average weighted score per person was discernibly high for children (2.24) and also for adults 1.34 thus illustrating dental fluorosis as a public health problem for inhabitants in Thambuttegama and especially among 12-15 year old adolescent children. This value was higher than 1.69 reported for Anuradhapura District among school children (Tennakoon,2004), and 1.85 and 1.89 for Galkulama and Hidogama but comparable with 2.29 reported for Thalawa (Abyaratna,2002).

However, in spite of 85.7% prevalence, 54.2% of children were unaware of dental fluorosis. Nevertheless among adults this discrepancy was minimal as 57.1% were

unaware of having dental fluorosis while the prevalence was 50.7%. Importantly 55.2% of children and 65.5% of adults reported not having any impact to their day to day life due to dental fluorosis. Self-assessed impact becomes important in contexts of scarce resources and lack of guaranteed long term cosmetic treatment for dental fluorosis. As dental fluorosis is highly prevalent perhaps people get adapted to it to the extent of normalizing exacerbated by the absence of widespread, affordable cosmetic dental treatment.

B. Discussion of specific objective 2: To investigate the relationship of nutritional status of people with the occurrence of fluorosis in endemic areas

Although dental and skeletal manifestations of fluorosis have been well-known the non skeletal entity of fluorosis, affecting the soft tissues and organs of the body, is a relatively new condition, confirmed through different studies conducted in India (Susheela and Bhatnagar, 2002 a,b). It is also established as at present that, fluoride ingestion over a period of time can affect the structure and function of cells, tissues, organs and systems giving rise to a variety of clinical manifestations (Sushhela and Jaine,1985). One of the common manifestation is diffuse aches and pains in the joints, ie.neck, back, hip, shoulder and knee without visible signs of fluid accumulation and abdominal cramps (Susheela and Bhatnagar, 2002 a,b). Such symptoms may be dismissed as functional, but may in fact be early signs of fluoride damage to tendinous insertions and ligaments as well as joint capsules (Anand and Roberts,1990:Ayub and Gupta,2006). The importance of detecting fluorosis at early stages becomes pertinent with contemporary research evidence. It has been reported that with a standardized early diagnosis, elimination of fluoride intake and supplementation of a diet rich in essential nutrients and anti oxidants fluorosis could be reversed (Susheela and Bhatnagar,2002 a,b).

However, as emerged from the findings of the present study, there was no substantial evidence for prevalence of early skeletal fluorosis among adolescents and adults of Thambuttegama as assessed by a check list of self-reported symptoms (Bharati et al.,2005) and performance of three physical tests (Susheela and Bhatnagar, 2002a,b). However, there is a published case report on skeletal fluorosis with spinal code compression from Kekirawa following consumption of water with high fluoride content for about 20 years (Disanayake et al.,1994). Moreover, among the minority who reported symptoms, commonly reported symptoms such as abdominal cramps and back-ache, joint pain and tingling both by children and adults could be due to excessive ingestion of fluorides.

There could be many plausible reasons for present findings. Firstly, early skeletal fluorosis as assessed by self-reported symptoms and physical tests could not be a problem among the majority of the sample of children and adults. Secondly, the sensitivity and specificity of the check list of self-reported symptoms and physical tests could not have been sufficient for the

present sample. For example, in the early stages of skeletal fluorosis people complained of arthritic symptoms, which has to be differentiated from those caused by such diseases such as rheumatoid and ankylosing spondylitis (Ayoob and Gupta,2006). Moreover, occupational exposures could give rise to many of the symptoms of the adults eg.farming. These factors could have resulted in more adults being reporting symptoms and difficulties in performing physical tests compared to children.

For early diagnosis of skeletal fluorosis, microradiographic techniques are more reliable than self-reported symptoms and performance of physical tests (Susheela and Bhatnagar, 2002a,b). However, for many parts of Sri Lanka with endemic fluorosis this is not practical and affordable. Hence it is useful to employ field-based approaches as above where diagnostic facilities are not available (Susheela and Bhatnagar, 2002a,b). Furthermore, for diagnosis of skeletal fluorosis is inherently associated with difficulties as at early stages symptoms that are manifested are so varied that they may be identifiable with those of various other diseases (Ayoob and Gupta, 2006). Therefore, battery of diagnostic tests has to be employed to arrive at a definitive diagnosis for skeletal fluorosis such as urinary and serum levels of fluoride and radiographs of the skeleton (Susheela and Bhatnagar, 2002a,b).Hence the investigations needed for a definitive diagnosis of skeletal and non skeletal fluorosis are: (1) fluoride levels in the blood (serum), urine, drinking water (2)radiographs of the region or joint where the patient had complaints such as pain and stiffness (3) forearm X-ray to look for intraosseus membrane calcification. Moreover, the forearm X-ray is essential for diagnosis of fluorosis at early stages as well as for differential diagnosis of fluorosis from other orthopaedic conditions. Hence, forearm X-ray becomes unique for diagnosis of fluorosis (Susheela and Bhatnagar, 2002a,b).

a) *The relationship between nutritional status assessed by BMI, and Occurrence of dental fluorosis*

The occurrence of dental fluorosis was more among children with low BMI compared to those with normal or high BMI. However, these differences were not statistically significant (Table B.1.1).These findings are comparable with that of Sampaio et al.,1999, in which nutritional status was not associated with dental fluorosis among Brazilian rural children aged 6-11 years. In the latter dental fluorosis was assessed by TF index as the present study, however nutritional status was assessed by height for age index as opposed to BMI.

There was no statistically significant relationship between the occurrence of dental fluorosis and nutritional status assessed by BMI among adults of the present study. There could be many reasons for present findings.

As the incidence of dental and skeletal fluorosis which are manifestations of the adverse effects of prolonged excessive ingestion of fluorides on mineralized tissue, is frequently high in areas of the world where endemic nutritional deficiencies exist, malnutrition is often considered as a predisposing factor in the occurrence of fluorosis (Manji et al.,1986). Furthermore, studies have also shown that malnutrition, deficiencies in micronutrients particularly Vitamin C and Vitamin D aggravate the fluoride toxicity (Susheela and Bhatnagar, 2002a,b). Furthermore, enamel opacities mimicking to dental fluorosis are associated with nutritional conditions such as malnutrition with deficiency of vitamins D and A or a low-protein energy diet (WHO,2001).

Dental fluorosis is also could be considered a s a manifestation of long term excessive fluoride intake upto six years of age from birth and ingestion of fluoride after about five years of age will not cause dental fluorosis (WHO,2001). The most sensitive period for dental fluorosis for the eight permanent incisor teeth is the period from birth to 5 years of age (ten-Cate et al.,1995). Therefore, it is plausible to speculate that nutritional status as assessed by BMI at a given point of time may not be associated with a manifestation of upto six years of age among adults as well as among children. However, this lack of association was more discernible among adults.

b) Reporting of symptoms & Performance of 3 –physical tests:exercsises

As emerged from the findings of the present study, there was no evidence for prevalence of skeletal fluorosis among children and adults of Thambuttegama as assessed by a check list of self-reported symptoms (Bharati et al.,2005) and performance of three physical tests (Susheela and Bhatnagar, 2002a,b).

There could be many plausible reasons for present findings. Firstly, prevalence of skeletal fluorosis as assessed by self-reported symptoms and physical tests was not evident in the children and adults. In the early stages, symptoms of skeletal fluorosis may resemble those of arthritis (Ayoob and Gupta, 2006). Therefore, it is essential to confirm the findings of self-reported symptoms and performance of physical tests by further investgations. In addition, there is evidence that anti oxidants play a protective role in fluorosis (Susheela and Bhatnagar, 2002a,b). Therefore, it is plausible to speculate that most of the participants of the present study consume a diet rich in anti-oxidants 1e.tea, fruits, vegetables and green leaves. However, dietary details were not investigated in the present study.

The relationship between daily minimum fluoride intake and occurrence of dental and skeletal fluorosis.

The World Health Organization (WHO) had recommended that fluoride exposure, should be monitored regularly for any fluoride supplementation programme in order to ensure that exposure to fluoride in a population is at an appropriate level (WHO,

1994: Mariño et al.,2006). This becomes pertinent in areas with endemic fluorosis and high fluoride levels in drinking water. In the present study daily minimum fluoride intake which was computed based on fluoride concentration on an early morning spot sample of urine by employing a conventional assumption. As spot samples are easier to collect, they have now superseded 24-h collection in investigational and diagnostic purposes (Akashi and Motizuki, 1990) and for fluoride analysis as well (Susheela and Bhatnagar, 2002a,b). This approach was further substantiated by the fact that although there are many routes of fluoride excretion, renal excretion is considered the main route for removal of inorganic fluoride from the body (Mariño et al.,2006).

As evident from the present study, in overall there were no statistically significant relationships between minimum daily intake of fluoride estimated based on fluoride levels in a morning spot sample of urine and occurrence of dental fluorosis and skeletal fluorosis assessed by a check list of self-reported symptoms and performance of three physical tests among children and adults.

There could be many plausible reasons for these findings. Firstly, as reported previously there was no sound evidence for prevalence of skeletal fluorosis based on self-reported symptoms and performance of physical tests. On other words they were not sensitive and specific enough to detect skeletal fluorosis in the study sample. Moreover, urinary concentration of many analytes such as fluorides may vary throughout the day, and therefore measuring their concentration in a spot urine sample may not be representative of 24 hour urine excretion (Zohouri, 2006). Hence, a method has been proposed to estimate 24 hour urinary fluoride excretion based on a spot sample of urine based on Fluoride: Creatinine ratio. It was not possible to conduct such a method on a community based study of this nature due to obvious resource constraints and practical difficulties. Besides, renal clearance of fluoride is both a pH dependent and a concentration dependent diffusion process (Mariño et al., 2006). In this context, there are many documented factors which influence renal clearance of urine, of which the most important are the urinary pH: if the urine is alkaline, the fluoride will be for the most part F^- , which cannot permeate the epithelium. Hence, there will be a decrease in the tubular resorption of fluoride and the renal clearance of fluoride will be increased. The opposite occurs under acidic conditions (Mariño et al., 2006). Although, urine is considered to be the most important fluoride excretion pathway, it has been estimated that 10-20% of ingested fluoride is not absorbed and is excreted in feces (Ekstrand,1996).Moreover urine flow rate (Ekstrand et al., 1998), differences in the composition of diet and the altitude of residence (Maguire et al., 2007) also have been known to be associated with renal clearance of fluorides.

The fraction of the total daily fluoride intake excreted via urine has been estimated in a few studies. In adults, the kidneys clear approximately 50% of the daily intake of fluoride and among school children the levels were shown to vary widely from 35% in sub-optimally and 52% in optimally fluoridated areas (Whitford, 1990:Villa et al.,2000: Ketley and Lennon, 2000: Haftenberger et al.,2001: Franco et al.,2005).

Nevertheless, there were no studies available for Sri Lankan population on the fraction of fluorides excreted via urine. There is only one published comparative study on urinary fluoride excretion in 4-year-old children in Sri Lanka and England (Rugg-Gunn et al., 1993). Accordingly the mean fluoride concentrations in urine were 1.19 mg/l (SD 0.63). However, as emerged from the present study mean fluoride concentrations for 12-15-year-olds were higher than the former:2.24 (SD 2.71). These differences in findings could be due to many factors such as 24hour urine collection of the former compared to morning spot sample of the latter, age differences and importantly differences in the water fluoride levels: 0.88 -1.1 Dambulla (former study) vs 0.02-8.63 in the present study.

To calculate total fluoride ingestion from total fluoride excretion it is often assumed that 50% of the absorbed fluoride dose is excreted and therefore it is suggested simply to double excretion to calculate ingestion and thought to be more valid for adults than children (Ketley and Lennon,2000). However, it was not possible to check the validity of this conventional assumption used for computing daily minimum fluoride intake in the present study. Besides, though it is generally agreed that fluoride ingestion produces toxic effects, the concentration which may have deleterious effects is a subject of controversy and the minimum threshold has not been definitely established (Jolly et al., 1968). Moreover, despite the real concern regarding dental fluorosis, there is no dose-response relationship for predicting risk (Martins et al., 2008). Hence, such factors could have influenced present findings. In addition, as fluoride intake was based on a sub-sample (145/382 children and 133/368 adults respectively) there could be a possibility of less statistical power to detect associations.

According to aforementioned findings, there could be many plausible reasons for moderate positive correlation in urinary and water fluoride levels among children (Table C.c). However, the low positive correlation in urinary and water fluoride levels among adults (Table-C.c), merit further investigations.

To best of knowledge there are no published studies conducted in Sri Lanka to assess the relationship between fluoride intake and occurrence of fluorosis. Therefore, it is important to conduct further studies to improve the methodological aspects on valid assessment of daily fluoride intake among Sri Lankan population.

Discussion for specific objective 3: To introduce a simple defluoridation method for the people those who consume excess amounts of fluorides and assess the effectiveness of the method in order to relive the acute symptoms due to fluorosis.

However, as emerged from the findings of the present study, there was no evidence for prevalence of acute symptoms attributed to fluorosis among children and adults of Thambuttegama as assessed by a check list of self-reported symptoms (Bharati et al.,2005)) and performance of three physical tests (Susheela and Bhatnagar,2002)). Therefore, the original statement of 3rd objective needed to be modified and re-

worded as "To introduce a simple de-fluoridation method (fluoride removing filters) for people who consume excess amounts of fluoride and assess the effectiveness of the method in terms of removal of fluoride, usage and effective usage.

Water consumption is undoubtedly the vital factor determining the level of fluoride needed (Mariño et al., 2006). Therefore, ingestion of excess fluoride, most commonly in drinking water can cause fluorosis which affect both skeletal and soft tissues. Paradoxically, low levels of fluoride intake help to prevent dental caries. Therefore, fluoridation of water is considered one of the public health achievements in the last centaury (CDC, 1999). Hence, the monitoring and control of drinking water quality has become critical in preventing and control of dental fluorosis (WHO, 2008). In this context, one of the most commonly recommended methods is by the measurement of urinary fluoride excretion and its comparison with normative values (WHO,1999). In the absence of noramative data for Sri Lankan 12-15 year old children and 35-44 year old adults, based on the urinary and water fluoride levels potential recipients were selected to distribute and introduce a simple defluoridation method. Water samples were collected during the dry season in order to increase the validity of findings. According to the findings the range of fluoride levels in water was 0.02-8.63 mg/l (Tables C.a &C.b)

Demonstrating, through pilot projects the efficacy of low-cost fluoride removal technologies is considered to be an important intervention to prevent and control effects of excessive ingestion of fluoride in endemic areas. The locally produced filter used in this intervention based on newly manufactured bricks broken into 10-15 mm in diameter as the filtering medium is designed to obtain 15 liters of water per day. The filtering medium: bricks are made up of clay and the chemistry of burnt clay is in the form of Silicates Aluminates and Hematite. When these materials are soaked in water for several hours it could turn to oxyhydroxides of iron, aluminium and silica. At this stage hydroxyl ions exchange with the fluoride ions in water, thereby reducing its fluoride levels (Padmasiri and Fonseka,1994). In general if the level of fluoride in drinking water source is above 2mg/l it has been recommended to change the bricks once in three months.

There are limited studies on long-term evaluation of fluoride filters conducted in Sri Lanka. Of one such study the follow up period was 60 days and the fluoride levels of de-fluoridated water at the end of the period was reported as 2 mg/l ((Padmasiri and Fonseka,1994)). According to researchers a reasonably good removal of fluoride could be obtained in 4-5 hours of retention time of water in filters but the best results could be obtained if water is fed and withdrawn in 24 hour intervals.

In the light of such evidence, aforementioned objective was achieved by the 2nd stage of the study which consisted of three components as described in the methodology section.

The fluoride filters manufactured by Wayamba Polymers Co. was the choice of simple defluoridation method for the present intervention based on recommendations

for sustainable fluoride filter (Jayawardena and Padmasiri,2006). For example sustainable design, easy construction and maintenance, utilization of indigenous material (newly manufactured brick broken into pieces of 15-20 mm diameter) to keep overall costs low and for ease of device maintenance, incorporation of renewable material into the device to help ensure generation of only minimal waste and to lessen negative environmental impact. In addition, the second investigator was well versed and experienced in community interventions, capacity building for usage and assessing effectiveness of aforementioned fluoride filters as well assessing their effectiveness (Jayawardena and Padmasiri,2006).). Moreover, participants were informed about fluoride levels in the water samples given and those were above 5 mg/l were advised to replace their sources of water by safe alternatives as the sustainability of performance of filters were claimed to be affected by higher fluoride levels in water. In addition, some participants who used water with fluoride levels >5mg/l were proceeding to obtain tap lines.

As revealed by the results (Table D 1) the fluoride filters were deemed an effective and simple defluoridation method for the people those who consume excess amounts of fluorides. As there were no significant findings on prevalence of early skeletal fluorosis based on self-reported symptoms and performance of physical tests, a deviation has to be made from the original objectives and it was decided only to assess the effectiveness in terms of removal of fluoride, usage and effective usage.
A practical demonstration was conducted for the recipients with special emphasis on practical aspects on utilization of fluoride filters. Recipients were also allowed to clear up their doubts by asking questions after the demonstration. Importantly, the intervention was made sustainable with community participation and involvement of all stakeholders. With the maximum collaboration of the MOH staff, RDS and the Dental Surgeon ADC Thambuttegama the intervention is sustained and monitored periodically in terms of adherence and perceptions of recipients in utilization of filters and practical difficulties encountered aimed at making remedial measures.

The present study followed up the recipients of fluoride filters in Thambuttegama MOH area over a period of 6 months and 14 months with two evaluations. However, the findings should be interpreted cautiously as the first evaluation had a non response rate of 16% and the second evaluation covered only 69.8% of the recipients of the first evaluation. According to findings, the proportion of filter users was 68.2% after 6 months and 75% at 14 months evaluation. The higher proportion of filter users at the second evaluation could be an over-estimation of actual figure due to incomplete coverage, due to obvious reasons such as dispersion of recipients over larger areas and their availability at the time of evaluation.

Findings of the self-administered questionnaire: Evaluation after 14 months

Household Information

Fifty percent of recipients were females and 59.1% of households had children below age of 8 years with the potential implication of susceptibility to dental fluorosis.

Another noteworthy observation was the majority of the item non-response for level of education was unusually high.

Inspection details of filters

The majority (96.9%) of filters in use seems to be storing water at the time of inspection and almost 100% of them contained the storage medium bricks and another 93.9% households using filters had stored bricks for future use. The maintenance of outside and inside of filters were deemed to be satisfactory in almost all instances. Moreover, the majority 93.2% received advice on filters and 86.4% received such advice from PHMM. Similarly, if they encountered a problem with regards to filters the advice was sought from the same source. The majority (45.5%) used filtered water at 24 hour intervals of feeding to the filter based on recommendations. However, another 13.6% used water as soon as feeding to the filter with implications. The majority 81.8% used wells as their source of water for the filter. As reported by the recipients, 43.2% used filtered water for drinking and another 40.9% used it for both drinking and cooking. In addition, 36.4% reported to be using other sources of water for cooking and another 25% for both cooking and drinking. All the households with children below age of 8 years were given filtered water for them to drink as reported by the adults. It is noteworthy that 56.8% of the households did not boil filtered water prior to drinking based on self-reports.

Factors related to use of fluoride filters

The respondents were asked on perceived benefits of using fluoride filters. Some of the potential benefits reported by them were prevention of staining/discolouration of teeth (52.3%), prevention of kidney disease (31.8%), to prevent diarrhoeal diseases (6.8%), to absorb hardness of water (9.1%), to make the water better (9.1%), to reduce fluoride concentration of water (4.5%), for better health (4.5%) and protection from germs (2.3%). Only 22.7% of filter users admitted difficulties in using them. The difficulties were liability to break (4.5%), breaking bricks into pieces (2.3%), kids poking into the filter (2.3%), troublesome nature (2.3%), difficulty in putting water to the filter (2.3%) and inadequate quantity of water (2.3%). The percentage of non users or defaulters was 15.9% at the first evaluation (after 6 months) and 25% after 14 months. The reasons stated by defaulters we re unavailability of regular supply of bricks (66.7%), broken tap of the filter (22.2%) and foul taste of filtered water (11.1%).

Moreover, suggestions for improvement aimed at improving the performance of filters were stated as *"increased capacity of the tank to store more water"* (56.0%), *"measures to ensure continuous supply of filtering medium: bricks"* (32%), *"placing tap lower than the present level"* (8%), *"placing a lid on the tube"* (4%). One of the remarkable finding of two evaluations was the declining trend of "effective users" of filters determined as 51.2% after 6 months and 36.4% after 14 months (Table D3). This could be attributed to issues such as perceived difficulties reported by the non-users in obtaining regular stocks of filtering medium: *newly burnt bricks broken into*

pieces. In addition, in both evaluations the findings could be influenced of social desirability bias ie.some defaulters trying to fill the abandoned filters as soon as they become aware of the evaluation and reporting that they have changed bricks within a period of 3 months in spite of steps taken to minimize this bias by making uninformed sudden visits. For example, at 14 months evaluation the majority of users 34.1% responded that they have changed bricks last in December 2008.

For concluding remarks, the present study constituted a reasonably comprehensive and novel approach to assess the effects of excessive ingestion of fluorides in people living in an endemic area with groundbreaking findings in spite of many constraints. Neverthess, the findings of the present study related to prevalence of acute symptoms attributed to fluorosis merits further investigation with methodological refinements. Sustainability of the introduced defluoridation method is a vital issue which needs special concern. Fluoride filters using newly burnt bricks could be considered as an effective method of de-fluoridation for endemic areas of fluorosis. Nevertheless, after 6 months, of their distribution there was evidence for declined number of users due to acquired tap lines and subsequent substitution of source of water for household use. In addition, the number of *effective users* appeared to be lowering down which could be attributed to practical problems such as difficulties in getting regular supply of bricks. The present study denotes one of the first attempts to assess the effectiveness of fluoride filters as a simple de-fluoridation method for people who consume excess amounts of fluoride in an endemic area of fluorosis in Sri Lanka. It had the added strength of two assessments and a long- term follow period extended up to 14 months after distribution of filters thus giving rise to many practical implications of its findings. Feedback from recipient is fundamental to assessing effectiveness of these de-fluoridation methods which should compliment assessment of fluoride levels in filtered water based on an upper threshold limit as used in this study. Importantly, there are basic issues such as ensuring a regular supply of bricks and making improvements to the design of filters which need to be considered in order to empower rural communities already burdened with many other aspects of their daily living in order to sustain their commitment to use fluoride filters.

VI) Conclusions

- The prevalence and severity of dental fluorosis is very high among 12-15 year old children as well as considerably high among 35-44 years-old-adults in Thambuttegama area. Accordingly 88.7% and 85.8% of the children had dental fluorosis according to Dean's index and TF index respectively. Moreover, among adults 53.5% and 49.3% were categorized as having dental fluorosis according to those two indices respectively. According to the severity, by Dean's index 24.8% of children and 16.7% of adults had severe form of fluorosis as assessed by Dean's index. In the summarized version of TF index, 62.5% of children and 37.9 % of adults had opacities only while 23.2% of children and 11.4% of adults had opacities and surface loss.

- Community Fluorosis Index:CFI was discernibly high for children (2.24) and also for adults 1.34 thus illustrating dental fluorosis as a public health problem for inhabitants in Thambuttegama and especially among 12-15 year old adolescent children.
- Prevalence of self-reported symptoms were low among children as the majority 76.2% were symptom free while only an 18.5% of adults rendered to be symptom free. Of those who reported symptoms abdominal cramps were the most common among children (17.1%) and backache among adults (60.0%). Knee joint pain and tingling were common among children and adults who reported symptoms.

- Of performance of three physical tests: Only 0.8% of both children and adults were unable to perform all three exercises.

- There was no relationship among nutritional status of people and occurrence of fluorosis:dental fluorosis assessed by TF index and skeletal fluorosis assessed by check list of self-reported symptoms and performance of three physical tests.

- There was no relationship among estimated minimum daily intake of fluoride and occurrence of fluorosis:dental fluorosis assessed by TF index and skeletal fluorosis assessed by check list of self-reported symptoms and performance of three physical tests.

- Fluoride filters were deemed an effective and simple defluoridation method for the people those who consume excess amounts of fluorides

- Check list of self-reported symptoms and performance of three physical tests should be assessed for their sensitivity and specificity in detecting skeletal fluorosis and spot samples of urine as a method of estimation of daily fluoride intake of an individual needs methodological improvements and validation

- By the end of 6 months of follow up overall there was 30% reduction in use of fluoride filters primarily attributed to replacement of source of water by tap lines.

- In two follow ups: 6 months and 14 months after distribution of filters there was evidence for declining number of users (15.9% to 25% respectively) as well as "effective users (fluoride levels of water in filters <0.8mg/l)" from 51.2% to 36.4%, which could be attributed to practical problems such as difficulties in getting regular supply of bricks.

- Importantly, there are basic issues such as ensuring a regular supply of bricks and making improvements to the design of filters which need to be considered in order to empower rural communities already burdened with

many other aspects of their daily living in order to sustain their commitment to use of fluoride filters.

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VIII) Problems if any, encountered during implementation of the project

Work plan was not on schedule due to delay in acquiring the bench top fluoride ion analyzer and problems encountered in calibrating the new instruments.

Section 4

Impact of Research results:

1) Relevance of results achieved to scientific advancement

- Identifying the importance of overall assessment of disease burden related to fluorosis
- Adding to the available evidence on the prevalence and severity of dental fluorosis in Anuradhapura as a major cause for concern and as major public health problem affecting adolescent.
- Identifying the importance of refinement of methodology in urine fluoride analysis eg. feasibility using a spot sample of urine for community based studies
- Innovative approach to identify the non-skeletal entity of fluorosis in order to mitigate the deleterious effects of skeletal fluorosis making use of check list of self-reported acute symptoms of fluorosis and physical tests
- Provision of baseline information for development of a check list of self-reported acute symptoms of fluorosis and physical tests as community based screening tools to detect soft tissue and skeletal fluorosis in endemic areas and rural settings where diagnostic facilities are scarce.
- Importance of water quality monitoring and surveillance: Identification of safe sources of drinking water
- Importance of validation of spot samples of urine by 24h urinary collection to estimate daily fluoride intake
- Implementation of a simple, scientifically proven defluoridation method designed in Sri Lanka, which uses locally produced filtering medium.
- Highlighting the need for long-term follow ups and perceptions of the recipients are fundamental to assessing the effectiveness of fluoride filters as a "simple and effective defluoridation method" complimented by determination of fluoride levels in filtered water based on an upper threshold limit ie.>0.8 mg/l
- Community participation and stewardship for sustainability and effectiveness of an intervention to ameliorate a public health problem in an area.
- Dissemination of information to school teachers, school children primary health care workers, clinicians, dental surgeons academics, geologists, water board authorities, environmentalisis to strengthen attempts for prevention, early detection and control of fluorosis
- Provision of baseline information to health authorities and policy makers for evidence-based policy formulation for prevention and control of fluorosis in endemic areas in Sri Lanka.

- Fostering inter-sectoral collaboration (public health professionals, geologists, environmentalists, clinicians, educational authorities, policy makers, politicians) for prevention, early detection and control of fluorosis
- Highlighting the need for further research related to symptoms attributed to fluorosis in endemic areas
- Highlighting the importance of sustainability of the introduced cost effective defluoridation method by addressing the practical difficulties

11) Relevance of results achieved to national/socioeconomic development

- Results are relevant in terms of reducing the burden of disease due to excessive ingestion of fluoride in endemic areas by primary, secondary and tertiary prevention methods which are evidence-based and cost-effective
- To reduce the health care budget spent on disease burden related to fluorosis
- To improve the economic productivity and well-being of people living in endemic areas of fluorosis
- To assess the long-term impact of fluoride filters as a de-fluoridation method among rural populations

111) Dissemination/application of research output:

A power point presentation is currently under preparation for local and international audiences.

Section 5

Miscellaneous

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

Equipment: Iron Sensitive Fluoride Electrode
Status: Functional

II) List of publications/communications arising from the project and/or presentations made at seminars, workshops etc.(Please attach copies): Nil.

Section 6

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

		Funds received Rs.	**Total expenditure Rs.**	**Balance available Rs.**
Personnel - Research student		.....	.....	
.....				
Technical Assistant		.....	.....	
.....				
Other		.....	.....	
.....				
Equipment – (Iron Sensitive Fluoride Electrode)	Foreign	291,500.00	217,000.00	74,500.00
	Local	171,000.00	166,500.00	4,500.00
(Fluoride filters)				
Consumables	Foreign	70,000.00	69931.75	68.25
	Local	-	-	
-				
Travel & Subsistence		327,882.00	252318.50	75563.50
Miscellaneous		42,000.00	41923.00	77.00
		---	---	---
	Total	**902,382.00**	**747673,25**	**154708.75**

		Rs. Cts.
Unspent balance of the funds received		---
Balance	-	154708.75
Funds received	-	902,382.00
Actual expenditure	-	747673.25
Cash Imp rest / Cash advance	-	00.00

Balance as at 01.04.2009	-	**154708.75**

Section 7

I **Grantees' signatures**

III **Comments of the Head of the department/signature**

Satisfactory

III **Head of the Institution's signature**

Deputy Director
Dental Institute
Colombo - 07.

Acknowledgements

On behalf of the College of Community Dentistry of Sri Lanka, the principal investigator and the co-investigators greatly appreciate the Director and the staff of the National Science Foundation of Sri Lanka for awarding a research grant for conducting this study. We are also grateful to the Dr J M Jayasundara Bandara, Deputy Director General of Dental Services for all the administrative support given by him for carrying out this research project. The cooperation extended by the Provincial Director of Health Services (NCP), the Regional Director of Health Services, Anuradhapura, Dr W M C T Bandara, Regional Dental Surgeon, Anuradhapura, Drs C Gallage, H Somasiri Medical Officers of Health, Tambuttegama and Dr K Jayaratne, Dental Surgeon, Adolescent Dental Clinic, Tambuttegama in carrying out this research project in Tambuttegama area is also greatly appreciated.

We wish to thank Dr AAHK Amarasinghe and Dr T M M H Tennakoon (who was then Regional Dental Surgeon, Anuradhapura), the collaborators for their invaluable contribution and the courage shown by them in the course of conducting this survey. It is noteworthy to mention the dedication and the hard work done by Dr Irosha Perera from the initial stages to the final report preparation stage in this research project. Her involvement in this study became a great strength for all of us. We also appreciate the contribution given by Dr N C Ratnayake, Dr A M I R Perera and Dr K A K D Perera in conducting this study.

We also express our sincere thanks for the valuable contribution made by the Public Health Midwives, Public Health Inspectors, School Dental Therapists and other members of the MOH staff in conducting field survey. Our gratitude goes to the participants who volunteered to take part in this study. Without their cooperation the entire study would not have been a successful exercise.

Finally our thanks are due to community members who cooperated with us and provided native refreshments to the investigators in the field.

Date: **Annexure: I** Serial No:

Survey to Study Health Effects of Excessive Intake of Fluorides

Part 1:

1 Name:

2 Gender: Male/Female

3 Occupation (Your/your father's/your mothers):

4 Date of Birth: Year: Month:

5 From where do you get drinking water for your family members?

6 From where do you get water for cooking purposes for your family?

7 Do you use a fluoride filter in your home? Yes/No

8 What is your opinion about the usage of fluoride filter?

9 What materials do you use for brushing your teeth?

10 How many cups of tea do you drink in a day?

11 How many times do you eat fish in a week?

12 How many times do you eat dry fish in a week?

13 Do you have dental fluorosis?

14 Are you happy with the appearance of your teeth?

Part 2

1 Do you have a feeling of pricking or numbness over your limbs? Yes/No

2 Do you feel pain in your joints? Yes/No

3 Do you feel pain in your body? Yes/No

4 Do you feel pain in your back area? Yes/No

5 Do you feel pain in your knee area? Yes/no

6 Do you have difficulty in bending your hands? Yes/No

7 Do you have difficulty in walking? Yes/No

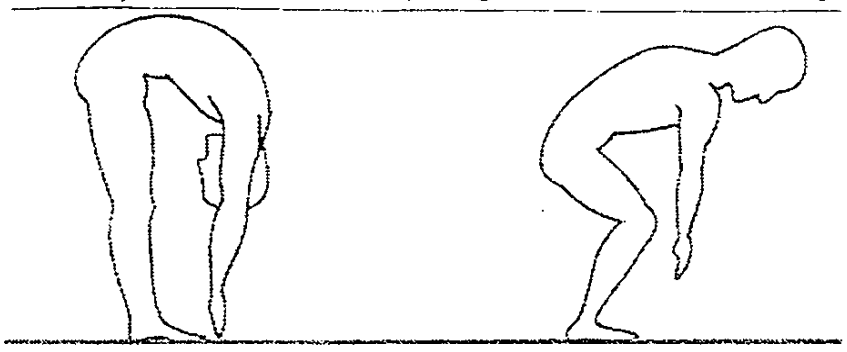
8 Do you get abdominal cramps? Yes/No

9 Do you have difficulty in breathing when bending forward? Yes/No

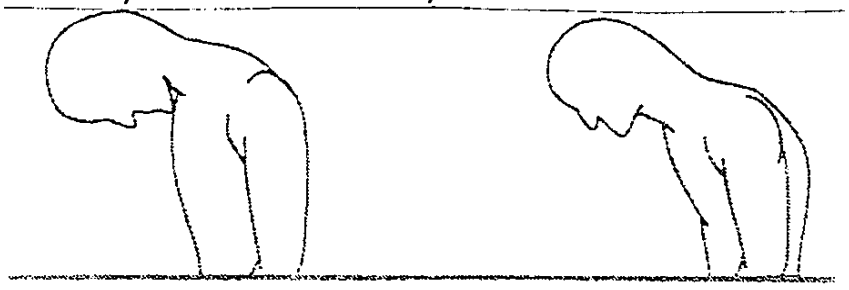
Part 3: Exercises

(Participants should be asked to perform these exercises after showing them the illustrated pictures)

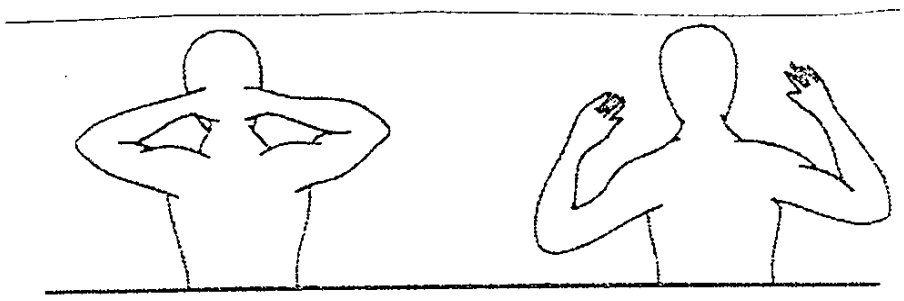
1 Ability to touch toes by fingers without bending knees



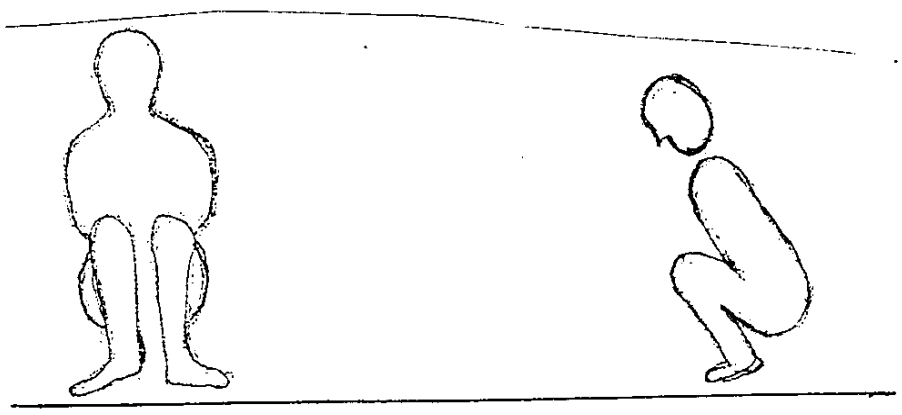
2 Ability to touch chest by chin



3 Ability to touch back of head by flexed hands



4 Ability to be in squatting position



Height: in meters

Weight: in Kg

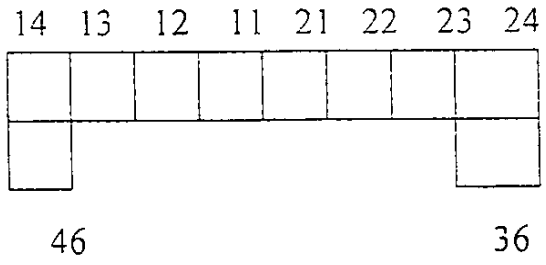
Fluoride concentration in urine:

Fluoride concentration in drinking water:

Fourth Part:

Enamel opacities/Hypoplasia

0 = Normal
1 = Demarcated opacity
2 = Diffuse opacity
3 = Hypoplasia
4 = Other defects
5 = Demarcated and diffused opacities
6 = Demarcated opacity and hypoplasia
7 = Diffuse opacity and hypoplasia
8 = All three conditions
9 = Not recorded



Ten index teeth should be examined on the buccal surfaces only. If any index teeth is missing, the relevant box is marked as "x".

Dental Fluorosis – Dean's Index

0= Normal
1= Questionable
2= Very Mild
3= Mild
4= Moderate
5= Severe
6=Excluded
9= Not Recorded

For both Dean's and TF indices the recordings are made on the basis of the two teeth that are most affected. If the two teeth are not equally affected, the score for the less affected of the two should be recorded.

When the teeth are recorded, start at the higher end of the index, i.e. "severe", and eliminate each score until a given condition is present. If there is doubt the lower score should be given.

Dental Fluorosis- TF Index

0 = Normal translucency of enamel remains after prolonged air-drying.
1 = Narrow white lines corresponding to the perikymata.
2 = *Smooth surfaces:* More pronounced lines of opacity that follow the perikymata. Occasionally confluence of adjacent lines.
Occlusal surfaces: Scattered areas of opacity <2 mm in diameter and pronounced opacity of cuspal ridges.
3 = *Smooth surfaces:* Merging and irregular cloudy areas of opacity. Accentuated drawing of perikymata often visible between opacities.
Occlusal surfaces: Confluent areas of marked opacity. Worn areas appear almost normal but usually circumscribed by a rim of opaque enamel.
4 = *Smooth surfaces:* The entire surface exhibits marked opacity or appears chalky white. Parts of surface exposed to attrition appear less affected.
Occlusal surfaces: Entire surface exhibits marked opacity. Attrition is often pronounced shortly after eruption.
5 = *Smooth surfaces and occlusal surfaces:* Entire surface displays marked opacity wtih focal loss of outermost enamel (pits) <2 mm in diameter.
6 = *Smooth surfaces:* Pits are regularly arranged in horizontal bands <2 mm in vertical extension.
Occlusal surfaces: Confluent areas <3 mm in diameter exhibit loss of enamel. Marked attrition
7 = *Smooth surfaces:* Loss of outermost enamel in irregular areas involving <1/2 of entire surface.
Occlusal surfaces: Changes in the morphology caused by merging pits and marked attrition.
8 = *Smooth and occlusal surfaces:* Loss of outermost enamel involving >1/2 of surface
9 = *Smooth and occlusal surfaces:* Loss of main part of enamel with change in anatomic appearance of surface. Cervical rim of almost unafffected enamel is often noted

දිනය

Annexure: I

අනුක්‍රමික අංකය

ෆ්ලෝරයිඩ් අධික ලෙස ශරීරගත වීමෙන් ඇතිවන සෞඛ්‍යමය බලපෑම් පිළිබඳ සමීක්ෂණය - තඹුත්තේගම සෞ .වෛ . නි . කොට්ඨාශය

<u>පළමු කොටස</u>

01. නම

02. ස්ත්‍රී / පුරුෂ

03. රැකියාව (තම /පියා /මව)

04. උපන් දිනය වසර මාසය දිනය

05. ඔබේ නිවසේ සාමාජිකයින් පානීය ජලය ලබාගන්නේ කොහෙන්ද?

06. ඔබේ නිවසේ සාමාජිකයින් ඉවුම්පිහුම් සඳහා ජලය ලබාගන්නේ කොහෙන්ද?

07. ඔබේ නිවසේ ජලය පෙරා ගැනීමට ෆ්ලෝරයිඩ් ෆිල්ටරයක් භාවිතා කරනවාද? ඔව් / නැත

08. ෆ්ලෝරයිඩ් ෆිල්ටරයක් භාවිතා කිරීම පිළිබඳ ඔබේ අදහස

09. ඔබ දත් මැදීමට ගන්නා ද්‍රව්‍ය

10. ඔබ දිනකට කිවරක් තේ කහට පානය කරනවාද?

11. ඔබ සතියකට කිවරක් මාලු ආහාරයට ගන්නවාද?

12. ඔබ සතියකට කිවරක් කරවල ආහාරයට ගන්නවාද?

13. ඔබට දන්ත ෆ්ලෝරෝසියාව තිබෙනවාද?

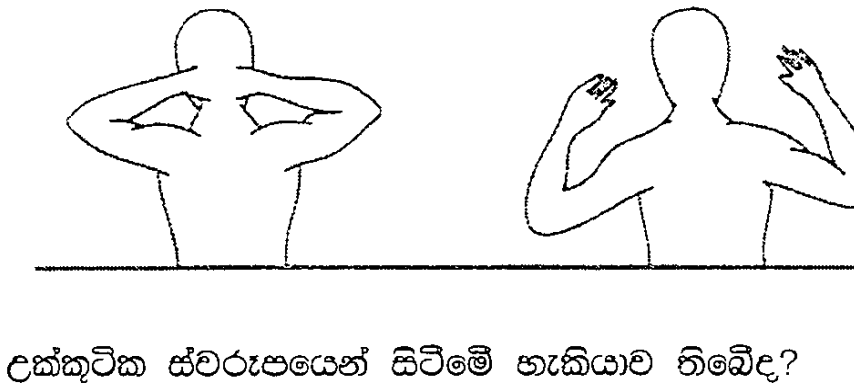
14. ඔබේ දත්වල පෙනුම ඔබ අසහනයට පත් කරනවාද?

<u>දෙවන කොටස</u>

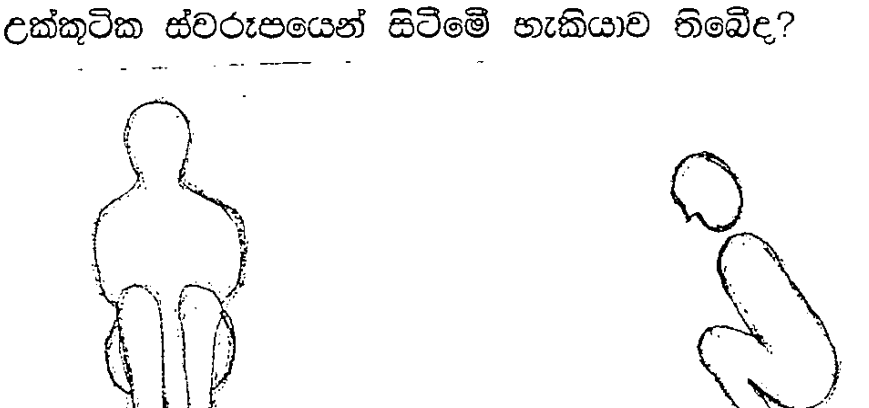
01. ඔබේ අත්පා වල ඉදිකටු ඇනෙනවා වැනි /හිරි ගතියක් දැනෙනවාද?	ඔව්	නැත
02. ඔබට සන්ධිපත් වේදනාවක් දැනෙනවාද?	ඔව්	නැත
03. ඔබට ඇඟපතේ වේදනාවක් දැනෙනවාද?	ඔව්	නැත
04. ඔබට පිටකොන්ද / තුනටියේ වේදනාවක් දැනෙනවාද?	ඔව්	නැත
05. ඔබට දණහිස්වල වේදනාවක් දැනෙනවාද?	ඔව්	නැත
06. ඔබට අත්පා නැමීමට / දිගහැරීමට අපහසු කරවන තද ගතියක් දැනෙනවාද?	ඔව්	නැත
07. ඔබට ඇවිදීමට අපහසු ගතියක් දැනෙනවාද?	ඔව්	නැත
08. ඔබට උදර ප්‍රදේශයේ කොරවීමක් වැනි දෙයක් දැනෙනවාද?	ඔව්	නැත
09. ඔබ නැමී සිටින විට හුස්ම ගැනීමේ අපහසුතාවයක් ඇත්ද?	ඔව්	නැත

<u>තෙවන කොටස - ව්‍යායාම</u> (ප.සෞ.සේ. නිළධාරිනිය විසින් ව්‍යායාම දැක්වෙන රූප සටහන් සහභාගිවන්නන් වෙත පෙන්වා අභ්‍යාසයන්ගේ යෙදීමට ඉඩ දෙන්න.)

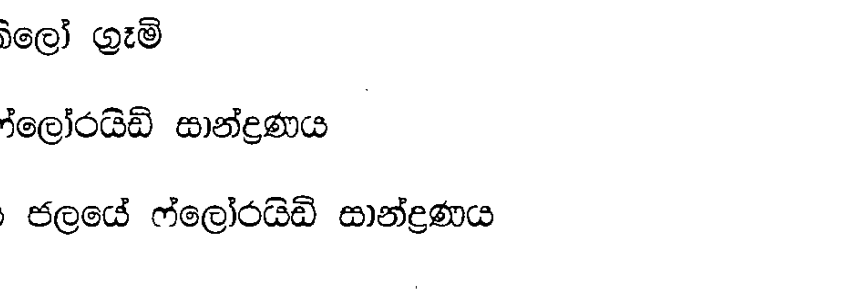
01. ඉඳුරියට නැමී දණහිස් නොනමා පයේ මහපට ඇඟිලි ඇල්ලමේ හැකියාව තිබේද? ඔව් නැත



02. හිස ඉඳුරියට නමා නිකට පපුවේ ස්පර්ශ කිරීමේ හැකියාවක් තිබේද? ඔව් නැත



03. දෑත් පිටුපසට නමා දෙඅත්ලෙන් හිස පිටුපස ස්පර්ශ කිරීමේ හැකියාව තිබේද? ඔව් නැත



04. උක්කුටික ස්වරූපයෙන් සිටීමේ හැකියාව තිබේද? ඔව් නැත

උස මීටර්

බර කිලෝ ග්‍රෑම්

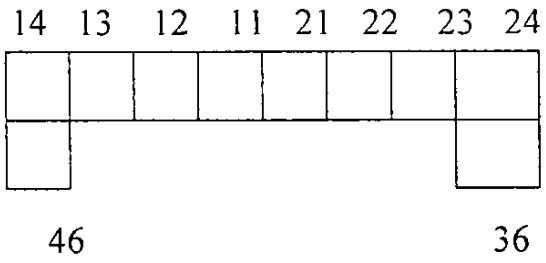
මුත්‍ර ෆ්ලෝරයිඩ් සාන්ද්‍රණය

පානීය ජලයේ ෆ්ලෝරයිඩ් සාන්ද්‍රණය

Fourth Part:

Enamel opacities/Hypoplasia

0 = Normal
1 = Demarcated opacity
2 = Diffuse opacity
3 = Hypoplasia
4 = Other defects
5 = Demarcated and diffused opacities
6 = Demarcated opacity and hypoplasia
7 = Diffuse opacity and hypoplasia
8 = All three conditions
9 = Not recorded



Ten index teeth should be examined on the buccal surfaces only. If any index teeth is missing, the relevant box is marked as "x".

Dental Fluorosis – Dean's Index

0= Normal
1= Questionable
2= Very Mild
3= Mild
4= Moderate
5= Severe
6=Excluded
9= Not Recorded

For both Dean's and TF indices the recordings are made on the basis of the two teeth that are most affected. If the two teeth are not equally affected, the score for the less affected of the two should be recorded.

When the teeth are recorded, start at the higher end of the index, i.e. "severe", and eliminate each score until a given condition is present. If there is doubt the lower score should be given.

Dental Fluorosis- TF Index

0 = Normal translucency of enamel remains after prolonged air-drying.
1 = Narrow white lines corresponding to the perikymata.
2 = Smooth surfaces: More pronounced lines of opacity that follow the perikymata. Occasionally confluence of adjacent lines.
Occlusal surfaces: Scattered areas of opacity <2 mm in diameter and pronounced opacity of cuspal ridges.
3 = Smooth surfaces: Merging and irregular cloudy areas of opacity. Accentuated drawing of perikymata often visible between opacities.
Occlusal surfaces: Confluent areas of marked opacity. Worn areas appear almost normal but usually circumscribed by a rim of opaque enamel.
4 = Smooth surfaces: The entire surface exhibits marked opacity or appears chalky white. Parts of surface exposed to attrition appear less affected.
Occlusal surfaces: Entire surface exhibits marked opacity. Attrition is often pronounced shortly after eruption.
5 = Smooth surfaces and occlusal surfaces: Entire surface displays marked opacity wtih focal loss of outermost enamel (pits) <2 mm in diameter.
6 = Smooth surfaces: Pits are regularly arranged in horizontal bands <2 mm in vertical extension.
Occlusal surfaces: Confluent areas <3 mm in diameter exhibit loss of enamel. Marked attrition
7 = Smooth surfaces: Loss of outermost enamel in irregular areas involving <1/2 of entire surface.
Occlusal surfaces: Changes in the morphology caused by merging pits and marked attrition.
8 = Smooth and occlusal surfaces: Loss of outermost enamel involving >1/2 of surface
9 = Smooth and occlusal surfaces: Loss of main part of enamel with change in anatomic appearance of surface. Cervical rim of almost unafffected enamel is often noted

Annexure: II

Survey on usage of fluoride filters - MOH area, Tambuttegama

Survey officer's code: Date: Time:

PHM area:

Information on household

1 Name of chief occupant:

2 Age: Years

3 Gender: Male/Female

4 Highest educational qualification you possess:

5 Number of family members below the age of 8 years

6 Number of family members above the age of 8 years

Observation check list

1 Do you use the fluoride filter provided? Yes/No
2 Do you put water to the filter? Yes/No
3 Do you put pieces of bricks to the filter? Yes/No
4 Do you have sufficient amount of brick pieces for future use? Yes/No
5 Maintenance: Inner – Satisfactory/Not satisfactory
Outer – Satisfactory/Not satisfactory
6 Is the filter in working order? Yes/No
7 If not in working order, state the reasons

Information on usage

1 Have you got instructions on usage of this filter? Yes/No
If yes, who has given the instruction?
2 Do you change the brick pieces time to time? Yes/No
If yes, how many times did you change the brick pieces?
When did you change the brick pieces last?
3 How long do you allow the water to remain in the filter before consumed?
4 How many water bottles do you take from the filter at a time?
5 Is that quantity of water adequate for the consumption of your family? Yes/No
6 What is the source of obtaining water for the filter? Well/Tank/Canal
7 From whom do you seek advice when you encounter problems with the filter?
8 For what purpose the filtered water is used by you? Drinking/cooking/for both drinking & cooking/any other

9	Do you use water other than the filtered water for any of the following purposes ? Drinking/cooking/for both drinking & cooking/any other
10	Do you allow the children in your family to drink filtered water? Yes/No
11	Do you boil the filtered water before drink? Yes/No
12	What do you expect from drinking filtered water?
13	What are the problems encountered by you during the use of this filter?
14	What are your suggestions and ideas about this filter?
15	Results of fluoride concentration of the random sample of water?

Annexure: II

තඹුත්තේගම සෞඛ්‍ය වෛද්‍ය නිලධාරී කොට්ඨාශය තුල පැවැත්වෙන ෆ්ලෝරයිඩ් පෙරන භාවිතය පිළිබඳ සමීක්ෂණය

සමීක්ෂණ නිලධාරී සංකේතය : ..... දිනය : ..... වේලාව : .....

පවුල් සෞඛ්‍ය සේවා නිලධාරී කොට්ඨාශය : .....

- ගෘහය පිළිබඳ මූලික තොරතුරු

1. ගෘහමූලිකයාගේ නම : .....
2. වයස : අවු. .....
3. ස්ත්‍රී පුරුෂ භාවය : .....
4. ඉහළම අධ්‍යාපන මට්ටම : .....
5. වයස අවු. 08ට අඩු සාමාජිකයින් ගණන : .....
6. වයස අවු. 08ට වැඩි සාමාජිකයින් ගණන : .....

- පිරික්සුම් වාර්තාව

1. ලබාදී ඇති ෆ්ලෝරයිඩ් පෙරනය භාවිත්‍ව කරනවාද ? - ඔව් / නැත
2. පෙරනයට වතුර දමා තිබෙනවාද ? - ඔව් / නැත
3. පෙරනයට ගඩොල් කැබලි දමා තිබෙනවාද ? - ඔව් / නැත
4. ඉදිරියේදී භාවිතා කිරීම සඳහා ගඩොල් කැබලි තිබෙනවාද ? - ඔව් / නැත
5. නඩත්තු කිරීම : ඇතුලත - (සතුටුදායකයි / සතුටුදායක නැත)
   පිටත - (සතුටුදායකයි / සතුටුදායක නැත)
6. පෙරනය ක්‍රියාත්මක තත්වයේ තිබේද ? - ඔව් / නැත
7. පෙරනය ක්‍රියාත්මක තත්වයේ නැත්නම් එයට හේතුව සඳහන් කරන්න.

.....

- භාවිතය පිළිබඳ තොරතුරු

1. මෙම පෙරනය භාවිත්‍ව කරන අන්දම පිළිබඳව ඔබට උපදෙස් ලබාදී තිබේද ? - ඔව් / නැත
   එසේ ලබාදී ඇත්නම් කවරෙක් විසින්ද ? .....
   .....
2. පෙරනයේ ඇති ගඩොල් කැබලි කලින් කලට මාරුකරනවාද ? - ඔව් / නැත
   ඔව් නම්. එසේකල වාර ගණන සඳහන් කරන්න .....
   අවසන් වතාවට ගඩොල් කැබලි මාරුකල දිනය / කාලය කවදාද? .....

3. වතුර පෙරණයට දැමීමෙන් පසු එම ජලය පාවිච්චි කරන්නේ කොපමණ කාලයකට පසුවද ?

   පැය .....

4. පෙරනයෙන් සාමාන්‍යයෙන් වතුර බෝතල් කියක් පමණ වරකට ලබා ගන්නවාද? .

5. එම ප්‍රමාණය ඔබේ පවුලේ පාවිච්චිය සඳහා ප්‍රමාණවත්ද? - ඔව් / නැත

6. මෙම පෙරනයෙන් පෙරා ගැනීමේ සඳහා වතුර ලබා ගන්නේ කුමන ප්‍රභවයෙන්ද?

   (ළිඳකින් / වැවකින්/ ඇළකින් ආදිය)

7. පෙරනය සම්බන්ධව ගැටළුවක් මතුවුවහොත් උපදෙස් ලබා ගන්නේ කාගෙන්ද?

8. මෙම පෙරාගන්නා ලබන වතුර භාවිත කරන්නේ කුමන කටයුතු සඳහාද?

   බීමට / ආහාර පිසීමට / ඉහත කාරණා මදක සඳහාමි

   වෙනත් කාර්යයන් සඳහා (සඳහන් කරන්න) . . . . . .

   . . . . . .

9. ඉහත සඳහන් කටයුතු සඳහා පෙරාගන්නා ලද වතුර හැර අනිකුත් වතුර භාවිතා කරන්නේද?

   බීමට / ආහාර පිසීමට / ඉහත කාරණා මදක සඳහාමි

   වෙනත් කාර්යයන් සඳහා (සඳහන් කරන්න) . . . . . .

   . . . . . .

10. පෙරාගන්නා ලද වතුර ඔබ පවුලේ කුඩා දරුවන්ට බීමට දෙනවාද ? - ඔව් / නැත

11. පෙරාගන්නා ලද වතුර බීමට පෙර උණුසර ගන්නවාද ? - ඔව් / නැත

12. පෙරාගන්නා ලද වතුර භාවිතා කිරීමෙන් ඔබ බලාපොරොත්තු වන්නේ කුමක්ද?

13. මෙම පෙරණය භාවිතයේදී ඔබ මුහුණ දෙන ගැටළු මොනවාද?

14. මෙම පෙරනය පිළිබඳව ඔබගේ යෝජනා මොනවාද ?

ජලයෙහි ෆ්ලෝරයිඩ් ප්‍රමාණය නිර්ණය කිරීම

	ෆ්ලෝරයිඩ් ප්‍රමාණය
අහඹු සාම්පලය	

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