Prevalence and factors associated with dental caries among school children (12 years age), in Nainital district, Uttaranchal, India, 2004

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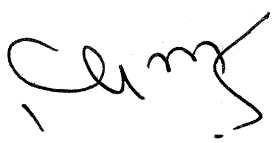
Certification

This is to certify that this dissertation, entitled **'Prevalence and factors associated with dental caries among school children (12 years age), in Nainital district, Uttaranchal, India, 2004'**, submitted by Dr. Harish Chandra Singh Martolia, in partial fulfillment of the requirements for the degree of Master of Applied Epidemiology, is the original work done by him and has not been submitted earlier, in part or whole, for any other (Publication or degree) purpose.



Date

Director

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Abstract

Background: Dental caries (tooth decay) is one of the most common diseases of childhood. We carried out a study to assess the prevalence and distribution of decayed, missing, and filled teeth (DMFT) among students studying in plain and hilly areas in Nainital district in India.

Methodology: We conducted a cross sectional survey among 802 students of 12 years of age studying in government schools in plain (n=400) and hilly areas (n=402) of rural Nainital district. Dental caries was measured using World Health Organization criteria. We also interviewed the students to collect information regarding socio-demographic factors, oral health behaviors, consumption of sweets and source of drinking water.

Result: In the plains, 153 of 400 children (38 %) were affected by caries. In the hills, 309 of 402 children (77 %) suffered from the ailment. Within each strata, parental education, occupation, economic status, oral health practices and food habits were not associated with caries. Among children from the plains, the prevalence of caries was higher among children who used spring water (23/38, 60 %) than those who used tube water (131/362, 36 %, prevalence ratio: 1.7, 95 % confidence interval: 1.25-2.24). Almost all the children from the hills drank spring water, which made a comparison impossible.

Conclusion: Caries is common among children in the Nainital district of Uttaranchal. Consumption of spring water, the only factor associated with the disease, probably explains the higher prevalence of caries in rural hilly area.

Despite improvements in the oral health of populations globally, problems still remain in many communities around the world particularly among under-privileged groups in developed and developing countries[1]. Poor oral health has a profound effect on general health and several oral diseases are related to chronic diseases. The experience of pain, problems with eating, chewing, smiling and communication due to missing, discolored and damaged teeth have a major impact on people's daily lives and well being. Oral diseases also restrict activities at school, at work and home causing millions of school and work hours to be lost each year throughout the world[2].

In 1983 oral health was declared as part of the Strategy for Health For All and in 1989, World Health Organization endorsed the promotion of oral health as an integral part of Health for All by the year 2000. In addition, World Health Day in 1994 was dedicated to oral health which also reflects the importance attached to this issue[3].

Oral diseases like dental caries, periodontal disease, tooth loss, oral mucosal lesions and oro-pharyngeal cancers and human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) related oral disease and oro-dental trauma are major public health problems worldwide[2].

In many developing countries, access to the oral health services is limited and these services are available only at regional and central hospitals in urban areas. Very little importance is given to preventive or restorative dental care[2]. Many developing countries in Asia, Africa and Latin America have a huge shortage of oral health personnel and oral health care mainly consists of pain relief and emergency care. In children and adults suffering from tooth decay, teeth are left untreated or are extracted to relieve pain and discomfort. Public health problems related to tooth loss and impaired oral function are therefore expected to increase in many developing countries[2]. The impact of oral diseases on individuals and communities, as a result of pain and suffering, impairment of function and reduced quality of life is considerable[4].

Dental caries and periodontal diseases have historically been considered the most important global oral health burdens. Dental caries is still a major health problem in most industrialized countries as it affects 60-90% of school-aged children and vast majority of adults. In most developing countries, the level of dental caries was low until recent years but prevalence rate of dental caries are now showing a steady increase. This is largely due to increasing consumption of sugar and inadequate exposure to fluorides[2]. The distribution and severity of dental caries varies from country to country[1]. Globally, decayed, missing, and filled teeth (DMFT) for 12 years olds were estimated 1.74 during 2001 and 1.61 during 2004[5]. The dental caries experience in children is relatively higher in Americas (3.0) and European regions (2.6) whereas the index is lower in African region (1.6) and

southeast Asian region (1.7). In South East Asia Region (SEAR), the DMFT indices vary from country to country. Among the SEAR countries the highest DMFT index was found in Republic of Korea where the index was 3.0 during 1991 and least DMFT index of 1.0 was in Bangladesh (2000), Myanmar (1993) and Nepal (2000) with 1.0 DMFT index[5].

Dental caries is an important health problem in India. In 1993, estimated DMFT score of India was 0.86 at the age of 12 years[5]. The prevalence of caries in different states of the country ranged from 6-17% in tribal children in district Dhar, Madhya Pradesh (1993)[6], to 68% in Mumbai, Maharashtra (1998)[7] and 80.0% in Chennai, Tamilnadu (2005)[29] whereas the mean DMFT in different Indian states ranged between 0.5 in Dhar district, Madhya Pradesh (1993) to 1.87 in Puttur, Karnataka (2000)[8].

School health programme is in operation in Nainital district of Uttaranchal. The dental caries was frequently reported among children during the school health surveys especially among the children in hills. Very little information, however, is available about the magnitude of the problem and factors associated with it. In view of this, we conducted a survey of dental caries among school children (12 years age) in rural hilly and plain areas of Nainital district, Uttaranchal, India during 2004. The objectives of the survey were, to estimate the prevalence of caries and to identify contributing factors associated with caries.

Dental caries is an infectious, microbiological disease that results in localized dissolution and destruction of the calcified tissues of the teeth[9]. Dental caries is one of the most common childhood diseases. The disease is preventable and measures such as the introduction of fluoride to the community water supplies, oral hygiene products and routine dental care prevent development of dental caries.

Dental caries is a major disease affecting a large population of the inhabitants of the world. The disease has a high morbidity potential and it impairs the quality of life of many people causing pain and discomfort. In addition, it places a heavy financial burden on public health services[1].

Dental caries was identified as one of the important problems among school children in Uttaranchal during school health surveys. The prevalence of disease however has not been quantified systematically. In view of this, we conducted a survey of dental caries among school children in hilly and plain areas of rural Nainital district, Uttaranchal.

3.1. Introduction

Dental caries is defined as chronic, irreversible disease of the hard structures of teeth characterized by demineralization of inorganic components of teeth and dissolution of organic substance of microbial etiology[10].

3.2. Historical background of dental caries[9]

Caries may be considered to be a disease of the modern age. Anthropologic studies of Von Lenhossek revealed that the dolicocephalic skulls of men from pre Neolithic periods (12,000 BC) did not exhibit dental caries. There is no evidence of caries found in relatively few teeth in skull fragments of the earlier known ancestors of human, Pithecanthropus. Evidence of caries was found in at least one skull of a Rhodesian man from the Neanderthal age.

3.2.1. Early civilization

Gold tooth picks found in excavation at Ur (Sumerians) in Mesopotamia, Babylonians and Assyrians-periodontal problems-gingival massage combined with various herbal medicines (clay tablets) in 3000 BC. Indian civilization, Sushrutha Samhita-numerous descriptions of serious periodontal diseases with loose teeth and purulent discharge and Charaka Samhita-Stressed on tooth brushing-the stick for tooth brushing should be bitter, pungent or astringent 1000 BC. Neem twigs are used till today. Hippocrates, the father of modern medicine discussed the functions and eruption of teeth.

3.2.2. Middle civilization

In 16th century AD, Peter Foreest, a Dutch physician, concentrated upon the harmful effects of "Sugar and all Sweet things." Barber dentists were sent from England to US in 16th century. Toothbrush was introduced into the western world in 1640.

3.2.3. Nineteenth Century

Skinner established in the New York City the first dispensary for the treatment of the poor, and dental service was offered in 1791. M. Taveace in Paris introduced the first form of Amalgam in 1826. Baltimore College of dental surgery marked the official birth of formal dental education in 1840. Dental Service became part of the charity hospital in Philadelphia in 1861. First children dental clinic opened in Strasbourg, Germany in 1865. M.L. Rhein of New York City urged dentists to teach their patients proper tooth brushing method in 1884. This was the only true campaign to prevent caries before first world war and got famous term "Oral Hygiene".

3.2.4. Early 20th Century

GM Wright suggested the form of a sub speciality of dental profession, which was later on called as dental hygienists in 1902. The dental corps of US army came into existence in 1911. United States founded dental department in US public health services in 1919. Dentist act was passed in England in 1921. Over 7000 previously unregistered dentists registered themselves.

3.2.5. 1930's and after

In 1931, Churchill identified the element fluoride. In 1945, USA launched first water fluoridation in Grand Rapid's on the 20th January 1945 with Muskegon city being kept as a control. The studies on water fluoridation were complete by two milestone studies in USA, namely the Newberg-Kingston study (1956) and Evanston-Oak Park study (1967). The study confirmed the cariostatic effects of fluoride at 1 PPM. In 1973, WHO established W.H.O. oral epidemiological data bank, which collects data on dental health and dental needs in many countries around the globe. In 1982, International conference on the declining prevalence of dental caries was organized by Forsyth Dental Centre, Boston. The major event in 1980's has been the marked reduction in dental caries among children in many developed countries.

3.2.6. Milestones in Indian Scenario

Dentist act (Article 16 of 1948) was passed by the Indian parliament in close association with All India Dental Association (now Indian Dental Association) on 29th March 1948. This act was amended on 1st July 1955. Draft plan for National Oral Health Policy was submitted to the ministry of health, Government of India on 8th October 1985.

3.3. Pathogenesis of dental caries[9]

The etiology of dental caries is complex and there is no universally accepted etiology for dental caries. There are some accepted theories of dental caries.

3.3.1. The legend of worm

The earliest description of tooth decay came from the ancient Sumerian text known as "The legend of the worm". The Japanese dental caries is described as Mush-ha, meaning hollow teeth. Chinese used the same terms. In India and Egypt the worm is considered as the cause of dental caries.

3.3.2. Endogenous theories

3.3.2.1. Humeral theory

Human body is made of four elements: blood, phlegm, black bile and yellow bile. Ancient Greek physician and philosopher state that, "dental caries is produced by internal action of acid and corroding humors". Hippocrates, the father of Medicine, refers this theory as "accumulated debris around teeth and to their corroding action". He also states that stagnation of juices in the teeth was the cause of toothache.

3.3.2.2. Vital theory

This theory is based on the concept that tooth decay originates from within the tooth itself.

3.3.3. Exogenous theories

3.3.3.1. Chemical (Acid) theory

The concept emerged in 17th and 18th century that the teeth were destroyed by acids formed in the oral cavity. Robertson (1835) wrote that decay caused by acid formed by fermentation of food particles around teeth.

3.3.3.2. Parasitic (Septic) theory

Dubos (1954) wrote that microorganisms can have toxic effects on tissue. Early microscopic observation of scrapings from teeth and of the carious lesions by Antony Van Leeuenhoçk (1632-1723) indicated that microorganisms were associated with the carious process. In 1843, ERDl described filamentous parasites in the membrane removed from the teeth. Ficinus in 1847, a physician, also observed filamentous organism in the enamel cuticle.

3.3.3.3. Miller's chempparasitic theory (Acidogenic theory)

W.D. Miller proposed this theory in 1890. He says that organisms can produce acid from fermentation of sugar and showed that several oral microorganisms have this feature and lactic acid is one of the major acids formed. He also demonstrated that that extracted human teeth could be demineralized by incubation in mixtures of bread and sugar with human saliva. Williams (1897) recognized that bacteria adhere firmly to tooth surface producing a gelatinous substance that might localize the acid to the surface of the tooth.

3.3.3.4. Proteolysis theory

Gottileb (1944) proposed the concept that initial attack on enamel might be the destruction of organic material rather than demineralization by acid. Thus

organic material would be attacked before the mineral phase of enamel. The proteolytic enzymes liberated by oral bacteria destroy the organic matrix of enamel, loosing the apatite crystals, so they are eventually collapses.

3.3.3.5. Proteolysis chelation theory

Schatz and Martin originated this theory in 1955. This proposes that some of the products of bacterial action on enamel, dentin and food and salivary constituents can form chelates with the calcium. Since chelates can be formed at neutral or alkaline pH, the theory suggested that demineralization of enamel could arise without acid formation.

3.3.3.6. Sucrose chelation theory

Eggers-Lura (1967) suggested that sucrose itself and not the acid derived from it, can cause dissolution of enamel by forming unionized calcium saccharates.

3.4. Consequences of caries

Initially caries remains asymptomatic, lodging of food particles between the teeth is the common complaint, if oral hygiene is not maintained, and it may lead to cavity formation. When caries reaches to dentin, the sensitiveness to hot and cold food substances causes pain and when the disease advances to pulp, pain becomes severe, resulting in inflammatory changes in the pulp that is peri-apical abscess commonly known as dental abscess[10]. Dental caries can result in loss of tooth structure, pain and tooth loss and can progress to acute systemic infection[9,10].

3.5. Epidemiology of dental caries

3.5.1. Global

Dental caries is still a major health problem in most industrialized countries, affecting 60 to 90 % of school children and vast majority of adults. It is also a preventable oral disease in several Asian and Latin American countries, while it appears to be less common and less severe in most African and Asian countries[1].

Decayed, missing and filled tooth (DMFT) and decayed missing and surface (DMFS) are the standardized and universally accepted indices for measuring carries in a population[11]. These indices are the numerical value describing the relative status of a population on a graduated scale. The index expresses the sum of decayed, missing and filled teeth. The maximum possible DMFT score is 32. When the index decayed, missing and filled surface is counted, the maximum DMFS score is 128. DMFT gives an average number of teeth affected per study subject DMFS gives average number of surfaces affected per study subject. Decayed missing filled tooth (DMFT) index measures lifetime experience of dental caries in permanent dentition. For assessing the problem of dental caries in a community, several age groups are classically targeted. This includes 5 years for primary teeth and 12, 15, 35-44, and 65-74 years for permanent teeth. However, prevalence in age group of 12 year is used for comparing the prevalence in different areas and also for monitoring the trend in a given setting[11].

In light of changing living conditions, it is expected that the incidence of dental caries will increase in many developing countries in[1,2]. According to World Oral Health Data Bank in 1980, decayed missing and filled tooth (DMFT) indices at 12 years were available for 107 of 173 countries. Of these, 51% had DMFT of 3 or less, while the remaining 49 % had higher values. In the year 2000, the data were available for 184 countries as recorded in the WHO Oral Health Country/Area Profile Programme. Of these, 68 % had less than 3 DMFT[5]. The DMFT index for different countries in Southeast Asia region are given in the following table.

Table: Decayed, missing and filled teeth (DMFT) index (12 years) in SEARO countries:

Country	Year	DMFT index
Thailand	2000-2001	1.6
Sri Lanka	1994-1995	1.4
Nepal	1999-2000	1.1
Myanmar	1993	1.1
Maldives	1984	2.1
Republic PR of Korea	1991	3.0
Indonesia	1995	2.2
India	1993	0.8
Bangladesh	2000	1.0
Bhutan	1985	1.4

3.5.2. Risk factors associated with dental caries:

Dental caries is widely recognized as an infectious disease disease induced by diet. Cariogenic bacteria, fermentable carbohydrates and susceptible tooth and host are the main players in the etiology of caries[13]. Caries risk is greatest if sugars are consumed at high frequency and are in a form that is retained in the mouth for long period. Sucrose is the most cariogenic sugar because it can form glucan that enables firm bacterial adhesion to teeth and limits diffusion of acid and buffers in the plaque[44]. Several studies have shown association of caries with

consumption of biscuits, cakes, sugar confectionery, chocolate confectionery and soft drinks[14, 15]. Studies have also demonstrated that young children are most likely to develop caries if they acquire *Streptococcus Mutans* at a young age. It appears that a high level of *Streptococcus Mutans* may be partly compensated by other parameters such as good oral hygiene and a non-cariogenic diet. Less than daily toothbrushing and a highly cariogenic diet are thus important risk factors, but they may interact so that if there is a balance of good and bad habits the development of caries may be controlled[13-15].

3.6.3.Caries and fluoride

Fluoride is a key agent in reducing the prevalence of dental caries[12]. Studies show that the adjustment of fluoride concentration in drinking water to the optimum level of 1 ppm in temperate climate is associated with a marked decrease in dental caries and does not cause any undesirable side effects[9]. Anticaries activities of fluoride are through following three ways [16, 17]:

1. By encouraging repair (remineralization) of early damage to enamel caused by acid produced by the breakdown of sugar by plaque bacteria[18]
2. By improving chemical structure of the enamel, making it more resistant to acid attack. Applying fluoride gel or other products containing a high concentration of fluoride to the teeth leaves a temporary layer of calcium fluoride-like material on the enamel surface.
3. By reducing the ability of plaque bacteria to produce acid[19].

The prevalence and incidence of dental caries at the community level can be controlled by the following public health approaches:

1. Water fluoridation
2. Salt fluoridation
3. Milk fluoridation
4. Development of affordable tooth pastes

Extensive data is available regarding the link between waterborne fluorides and dental caries and dental fluorosis, development and evaluation of fluoride toothpastes and mouth rinses. These data sets have been summarized through several systematic reviews[20-24]. These reviews concluded that

1. Water fluoridation reduces the prevalence of dental caries by an average of 15% and reduces the incidence of caries by an average of 2.3 dmft/DMFT in children aged 5-14 years[25]
2. Fluoride toothpastes reduce the DMFT 3 year increment (number of new dental caries developing over three year period) by 23% [22,23]
3. There is no credible evidence that water fluoridation is associated with any adverse health effect [20,21]
4. At a fluoride level of 1 ppm in water, an estimated 12.5% of exposed people would have fluorosis that they would find aesthetically concerning[20]. The risk however is substantially higher in areas where water is naturally fluoridated and lower in areas in which fluoride concentration in water has been adjusted [25,26].

3.6.4. Dental caries in India

Dental caries is a public health problem in India with a prevalence as high as 60-80% in Indian children [27]. The prevalence of caries among 12 years old children in India in 1993 was 36% with an average of 0.86 DMFT[5]. The prevalence however varies in different parts of the country. The prevalence of caries and DMFT indices in different states are summarized in the following table. Uttaranchal is a newly created state and no data is available about problem of dental caries in the state.

Table: Prevalence of dental caries and mean DMFT index among 12 years old children in different states of India.

Sl. No	Place/state	Year of study	Prevalence (%)	DMFT index	Reference
1	Thirvananthapuram, Kerala	2005	27	0.5	28
2	Chennai, Tamilnadu	2005	80	3.94	29
3	Pondicherry	2003	22.3	0.4-0.5	30
4	Bhopal, Madhya Pradesh	2003	57	1.6	31
5	Belgaum, Karnataka	2002	45.12	1.18	32
6	Cuttack, Orissa	2002	64.3	2.38	33
7	Puttur, Karnataka	2000	59.6	1.25	34
8	Haryana (rural)	1999	39.4	1.03	35
9	Mumbai, Maharashtra	1998	68.02	--	36
10	Bhiwandi, Maharashtra	1998	56.93	1.25	37
11	Dhar district, Madhya Pradesh	1993	6-17	0.5-1.4	38

3.7. Prevention and control of dental caries

Some of the important priority action areas for prevention and control of dental caries are:

3.7.1. Oral health and fluorides: Research has shown that fluoride is most effective in dental caries prevention when a low level of fluoride is constantly maintained in the oral cavity[39]. The goal of community-based public health programmes, therefore, should be to implement the most appropriate means of maintaining a constant low level of fluoride in as many mouths as possible. Fluorides can be obtained from fluoridated drinking-water, salt, milk, mouthrinse or toothpaste, as well as from professionally applied fluorides; or from combinations of fluoridated toothpaste with either of the other fluoride sources. There is clear evidence that long-term exposure to an optimal level of fluoride results in diminishing levels of caries in both child and adult populations. As the fluoridated toothpaste is a highly effective means of caries control, WHO strongly recommends that every effort must be made to develop affordable fluoridated toothpastes for use in developing countries. The use of fluoride toothpastes being a public health measure, it would be in the interest of countries to exempt them from the duties and taxation applied to cosmetics [39].

3.7.2. Diet, nutrition and oral health: Diet and nutrition affects oral health in many ways. Dental diseases related to diet include dental caries, developmental defects of enamel, dental erosion and periodontal disease. Nutrition also influences craniofacial development, oral cancer and oral infectious diseases. The public health community involved with oral health should

1. Implement nutritional counselling, covering not only the general health aspects of good nutritional behaviour but also emphasizing the aspects

directly linked to oral health. The post-eruptive effect of sugar consumption is one of the etiologic factors for dental caries.

2. Facilitate awareness-raising activities in the promotion of breastfeeding. Among other important health benefits, breast milk prevents the occurrence of rampant early childhood caries. Early childhood caries is caused by frequent and prolonged exposure of the teeth to sugar and is often the result of a child going to bed with a bottle of a sweetened drink or drinking at will from a bottle during the day.
3. Advise on the benefits of decreasing the consumption of sugary soft drinks, which is a major risk factor in dental caries. Dental erosion also seems to be a growing problem and in some countries an increase in erosion of teeth is associated with an increase in the consumption of beverages containing acids.

3.7.3. Oral health through Health Promoting Schools: Oral health promotion through schools has several advantages. Firstly, students can be accessed during their formative years, from childhood to adolescence. These are important stages in people's lives when lifelong oral health related behaviour as well as beliefs and attitudes are being developed. Secondly, the burden of oral disease in children is significant. Most established oral diseases are irreversible, and would last for a lifetime and have an impact on quality of life and general health. Schools can provide a supportive environment for promoting oral health. School policies, the physical environment and education for health are essential for the attainment of oral health and control of risk behaviours, such as intake of sugary foods and

drinks, tobacco use and alcohol consumption. Schools can thus provide a platform for the provision of oral health care, i.e. preventive and curative services.

WHO's Global School Health Initiative, launched in 1995, is designed to improve the health of children, school personnel, families and other members of the community through schools. The WHO Global School Health Initiative consists of four broad strategies [40]:

1. Building capacity to advocate for improved school health programmes.
2. Creating networks and alliances for the development of Health Promoting Schools.
3. Strengthening national capacity.
4. Carrying out research to improve school health programmes.

3.7.4. National Oral Health Care Programme

Dental caries is a public health problem in India with a prevalence as high as 60-80% in Indian children [27]. Apart from this, about 30% of children suffer from malaligned teeth and jaws affecting proper functioning of the dento-facial apparatus [41]. Lack of awareness about dental diseases has resulted in gross neglect of oral health. There is no component of oral health in the present health care system of India. The grass-root level health workers and doctors do not have adequate knowledge about oral hygiene and prevention of oro-dental problems. All the above factors have resulted in poor oro-dental health of our population[42]. The National Oral Health Care Program was launched in 1999 to combat the ever

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increasing patient load and reduce the morbidity due to oro-dental problems in the country. The Directorate General of Health Services and Ministry of Health and Family Welfare, Government of India launched this primary preventive oral health care program focussed on primary prevention [43]. The main focus of National Oral Health Care Program is prevention through generation of awareness. Thus for this purpose, oral health education of the school children and public is the main strategy and use of IEC material for awareness generation is the major component of the oral health. The preventive strategies recommended for the control of dental caries in the national programme include creating awareness about maintenance of oral hygiene, sugar control and proper diet and promotion of fluoride tooth-paste and mouth rinses.

3.7. Summary

Prevalence of dental caries still is high in many country of the world. Initially prevalence was higher in the industrialized countries as compared to African and Asian countries. Dental caries is declining in the industrialized countries whereas prevalence is showing an increasing trend in many developing countries. Fluoride is protective for dental caries and one of the main reasons for declining trend of caries in industrialized countries is widespread use of fluoridated toothpaste and water/salt fluoridation programme.

4.1. Study area

Nainital district is one of the 13 districts of the state of Uttaranchal with a population of 7,62,912. Geographically, Nainital district is divided in hilly and plains areas. The hilly part of the district is about 2,400 meters above the sea level having an average yearly rainfall of 2,840 mm. 65 % of the population resides in the rural areas in the district.

4.2. Study design and setting

We conducted an analytical cross sectional study in two strata i.e. hilly and plain areas of rural Nainital district, Uttaranchal.

4.3. Study population

We conducted the survey among the children of 12 years of age studying in government junior high schools (6 to 8 standard).

4.4. Sample size

We could not find data on the prevalence of caries among school children in Nainital district or Uttaranchal state. Hence, we assumed that 55 % of the school children (12 years) in the hill areas and 45% in the plain areas suffered from caries. Assuming the confidence interval of 95 % and power of 80%, we calculated the sample size for each strata as 393 [45]. We inflated the sample size to take care of absenteeism in schools. Therefore, our overall sample size was 800 children, 400 from rural hill area and 400 children from rural plain area.

4.5. Sampling procedure

We listed all the junior high schools (6^{th} to 8^{th} standard) from rural hilly and plain areas of Nainital district from education department. We selected schools from both hilly and plain areas purposively, so that they would be representative of their respective areas. We interviewed 802 children, of which 402 were from rural hilly and 400 from rural plain area.

4.6. Study Team

The study team consisted of the principal investigator, one male health supervisor and one female health worker.

4.7. Data collection instrument

We used pre-tested structured questionnaire for the study to collect information regarding socioeconomic status of the family, oral health practices, eating behaviours and knowledge about caries. We examined the teeth of the children focusing on number of teeth affected and surfaces involved.

4.8. Preparatory works

4.8.1. Training

The principal investigator underwent two days training at Sri Ramachandra Medical College and Research Institute (SRMC-RI), Deemed University, Porur, Chennai in diagnosis dental caries and calculating DMFT and DMFS indices. The investigator also attended out patient department at Sushila Tewari Memorial Medical College, Haldwani, Uttaranchal, for five days.

4.8.2. Definition

We followed the WHO recommended method for oral health surveys to identify dental caries [11]. We defined caries as a localized dissolution and destruction of calcified tissues of the teeth looking black in colour.

4.8.3. Preparation of questionnaire

We prepared a structured questionnaire in English and then translated to Hindi and back-translated into English for quality assurance purposes. After that we again translated the questionnaire to Hindi and pre-tested in a nearby school. After necessary corrections we used the questionnaire in the field for data collection. The questionnaire was designed to collect information about socioeconomic status of the family, food habits and health seeking behaviors of the children. We also assessed the awareness about dental caries among the children.

4.8.4. Ethical issues

We explained the objectives of the study, study procedure to the school teachers and students in the class and mentioned that the participation in the study was voluntary and they may withdraw from the examination at their will. We then interviewed and examined the study subjects after obtaining the verbal consent from the children and the teachers. We ensured confidentiality of the information, we used no identifiers in the database, and instead we designed confidential codes.

4.9. Data collection

We visited the schools and selected the schoolchildren aged 12 years for the survey from the school register. After obtaining consent, we interviewed and examined the participants in the daylight with the help of a two medium-celled torch. All the participants rinsed their mouth before examination. We examined the participants without help of any instrument. We used new batteries after examination of every 50 students.

4.10. Data Analysis

We calculated the prevalence of dental caries for each strata. We calculated the DMFT using total number of teeth decayed, missing and filled as numerator and total number of children under study as denominator. We calculated the prevalence ratios of caries according to selected risk factors and their 95% confidence intervals (CI). We analyzed the data using Epi-info 6.04 software.

5.1 General characteristics

51.5% of the children in hills and 54.8% of children in plains were females. 66.7% of the children in hills and 55.5% of children in plains belonged to higher caste (Table 1).

5.2. Prevalence of caries

The prevalence of caries among school children in hills and plains was 77% (95% CI=72.6%-80.8%) and 38.9% (95% CI=33.8%-43.3%) respectively. The prevalence in hills was significantly higher than in plains (χ^2=119.4, p=0.0000) (Table 1). In both the areas, the prevalence did not differ among sexes (Hills-: prevalence in males: 74.4%, females: 79.2% χ^2=1.1, p=0.30; Plains: prevalence in males: 41.4%, females:36.1% χ^2=0.99, p=0.32). In hills, the prevalence was higher in higher castes as compared to other castes (44.5% vs. 29.8%, χ^2=9.7, p=0.002).

5.3. DMFT and DMFS indices

The mean DMFT index in hills was 2.2 whereas the index in plains was 0.7 (Table: 2). The proportion of decayed tooth in hills and plains were 94.8% and 95.8% respectively. The DMFS index in hills and plain was 3.6 and 1 respectively.

5.4. Factors associated with caries

In both areas, prevalence did not differ with respect to literacy status and occupation of parents, socio-economic status of family, consumption of sweets and tea and oral hygiene practices like brushing teeth with tooth brush, daily brushing and changing of tooth brush every six months (Table 3 and 4). In the

plains, the prevalence was lower in school children drinking tube well water (36.2%, 131/362) as compared to those drinking spring water (60.5%, 23/38, prevalence ratio=0.6, 95% confidence interval=0.45-0.80). In hills, spring was the main source of drinking water and only three children (0.7%) consumed tube well water.

5.5 Awareness about oral health

During 2004, 49.5 % (199/402) children in hills and 24 % (97/400) in plains had at least one attack of tooth ache. The majority of children in hills (95%, 382/402) and plains (97%, 389/400) however told that they never consulted the dentist for any tooth related problems. More than 50% children in the hills and plains informed that they would go to government hospitals for treatment of toothache (Table-5).

Important reasons for developing caries as mentioned by school children in hills and plains were eating of sweets (41.8 % and 35.8 %), not brushing teeth regularly (41 % and 32 %), not rinsing the teeth after foods (6.2 % and 10.8 %) and consumption of tobacco (2.2 % and 4.8 %). 18.7 % children in hills and 16.8 % in plains were not aware about the reasons of developing caries. 34.5 %(139/402) of the children in the hills and 11.7 % (47/400) children from the plains informed that they did not attend school for at least one day during last one year due to toothache.

The findings of the present study revealed that the prevalence of dental caries was about two times higher in the rural hilly area in Nainital district as compared to plain areas of the district. The DMFT and DMFS indices, which indicate the severity of caries, also were higher in hills as compared to plain areas. The prevalence of caries in plain area is as in other parts of India while prevalence is high in the hilly area of Nainital district.

We considered several factors such as parent's education, parents' occupation, brushing habits, use of brush, consumption of tea and sweets, source of drinking water, socioeconomic status of the family and found no association with dental caries. In plains, caries prevalence was significantly lower in children drinking tube well water compared to children drinking spring water. Almost all the children from the hills drank spring water, which made a comparison impossible. Consumption of spring water, the only factor associated with the disease, probably explains the higher prevalence of caries in rural hill area.

Dental caries is common in the rural areas of the Nainital district of the Indian state of Uttaranchal, with a higher prevalence in the hills than in the plains. This high prevalence is all the more a source of concern that the population lacks awareness about the problem and its causes. The disease, in both the areas was not associated with oral health practices, food habits of children and education, occupation and economic status of parents. However, in the plains, the prevalence was lower among those who consumed tube well water. Overall, this information allows formulating recommendations for prevention.

As per the WHO global report, the overall prevalence of caries in India in 1993 was 36% in with a mean DMFT of 0.86 [5]. However, according to specific studies, the prevalence was heterogeneous in the country, ranging from 6-17% among tribal children in Dhar district in Madhya Pradesh[38] (1993) to 80% in Chennai[29] (2005). This variation was also reflected in the mean DMFT that ranged between 0.4 in Pondicherry[30] (2003) and 3.94 (2005) in Chennai[29]. While the prevalence in the plain areas of Nainital was comparable with those observed in most others states of India, the prevalence of 77% that we measured in the hills was higher than the prevalence reported in many parts of country. Teeth damage due to caries is a lifelong experience but development of caries is preventable. Thus, prevention is of prime importance in high endemic areas. While the population of Nainital was affected by caries, there was little awareness in the population

regarding the consequences of caries and the prevention methods available. Furthermore, in Nainital, the decayed component of DMFT exceeded 90%, indicating the need for treatment. More than half of children reported past histories of toothaches. Overall, these results indicate the need to engage the rural population in oral health issues, including caries prevention, and to provide curative care for those affected.

Reports from various countries in the world and from India suggested that low literacy[46, 47] and family income [48] are associated with caries. More specifically, epidemiological studies along with theoretical rationale suggests that consumption of sugar confectionery [14], candy [46,47], sugar [49], sugary drinks[46,47] and tea [50, 51] are significant risk factors for caries. Milgrom *et al* [15] observed that consumption of food containing high cariogenicity score (food cariogenicity combined with the frequency of consumption) was found to be a significant risk indicator of dental caries.

Epidemiological studies that documented an association between caries and dietary practices used elaborate methods to estimate the intake of food items. These included four-day weighted dietary records [14], a "sweet preference inventory" [49] and a precise assessment of the sucrose level in dietary intake [52]. While some dietary factors can increase the risk of caries, good oral hygiene practices including rinsing mouth after eating food and use of toothbrushes are associated with a lower risk of caries. Fluoride toothpastes and mouth rinses

reduce the DMFS 3-year increment by 24-26% [22,23]. In Nainital district, self reported dietary and oral health practices were not associated with caries in any of the two areas studied. Two explanations may account for this absence of association. First, it is possible that our data collection procedure based upon self-reports by school children was not sufficiently precise to document such an association. We were unable to validate the information we collected from children with the parents since we conducted the study in the schools. Second, we may have lacked statistical power to document such an association in the presence of another factor -the type of water supply- that was strongly associated with the disease. Our data did not provide evidence to test these two hypothesized explanations.

Our study indicated that the source of water supply was the factor most strongly associated with caries in Nainital. In the plains, the prevalence of caries was lower among children who drank tube well water (36%) than among those who drank stream water (60%). In the hills, stream water was the main source of drinking water for the vast majority of the children, preventing any comparison with those drinking tube well water. However, the prevalence of caries in the hills (77%, 95% CI= 72.6-80.8) was comparable to the prevalence of caries among plain children who drank stream water (60.5%, 95% CI= 44.5-75.0). Thus, the source of drinking water may explain the difference of prevalence of caries in two areas. Fluoride content in the drinking water from tube well appears to be the most likely explanation for the lower prevalence of caries in plains. Several

studies have established the role of natural and artificial fluorides in the prevention of caries. Higher fluoride level in drinking water was an important factor that accounted for lower prevalence of caries in a number of settings. In addition, water fluoridation reduces the prevalence of dental caries [12].

Our study suffered from a number of limitations. First, several age groups are classically targeted to assess the prevalence of caries in a community. This includes 5 years for primary teeth and 12, 15, 35-44, and 65-74 years for permanent teeth. We restricted this survey to children who were 12 years of age as (1) they were easily accessible in schools and (2) this age has been chosen to compare the frequency of caries internationally and to monitor trends in a specific setting.[1] Second, faced with logistical constraints and hard to reach areas, we selected schools purposively. We selected governmental schools in three of the five blocks in hills and two of the three blocks in plains. While we aimed at being representative, our sampling strategy cannot be considered as a true statistical sample. Third, we limited our sample to governmental schools. This choice is unlikely to have affected our results to a great extent since the majority of children are studying in government schools in rural Nainital. Fourth, we were unable to test the drinking water for fluoride content and thus were unable to test the hypothesis that the association between the source of drinking water and caries was a consequence of the fluoride content of the water.

In conclusion, caries are highly endemic in the children of the rural hills of Nainital and the high prevalence is probably a consequence of a low fluoride content in the stream water predominantly drunk there. None of the other factors studied were found to be associated with dental caries.

8. Recommendations

On the basis of the results of the study we proposed the following recommendations:

1. Fluoride toothpastes should be made available in the hills.
2. Periodic screening and referral of school children should be organized through school health programmes to provide necessary care.
3. Schools should organize oral health campaigns to increase the awareness about the disease among children and to engage them in protective behaviours.
4. Water analysis studies, including fluoride content, should be carried out in order to understand the role of the stream water used to drink in the formation of caries.

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Table 1: Prevalence of caries among schoolchildren 12 years of age according to selected demographic and sociological characteristics, Nainital district, Uttaranchal, India, 2004

			Children with caries	Total	Prevalence (%)
Hills	Sex	Male	145	195	74
		Female	164	207	79
	Caste	Schedule tribe	3	4	75
		Schedule caste	91	126	72
		Backwards caste	3	4	75
		Others	212	268	79
	Religion	Hindu	309	402	77
		Muslim	0	0	0
	Overall		309	402	77
Plains	Sex	Male	75	181	41
		Female	79	219	36
	Caste	Schedule tribe	3	4	75
		Schedule caste	41	142	29
		Backwards caste	9	32	28
		Others	101	222	45
	Religion	Hindu	150	394	38
		Muslim	4	6	67
	Overall		154	400	38.5

Table 2: Decayed, missing and filled tooth (DMFT) and decayed, missing and filled surfaces (DMFS) among school children (12 years) in rural hills and plains of Nainital district, Uttaranchal, India, 2004.

	Number of children under survey	
	Plains (n=400)	Hills (n=402)
Decayed tooth	271	845
Missed tooth	11	46
Filled tooth	00	00
Surface	403	1454
DMFT	282/400=0.70	891/402=2.2
DMFS	403/400=1.00	1454/402=3.60

Table 3: Prevalence of caries among schoolchildren in hills according to selected characteristics, Nainital district, Uttaranchal, India, 2004

	Exposed			Unexposed				95 %
Characteristics	No. with caries	Total	Prevalence (%)	No. with caries	Total	Prevalence (%)	Prevalence ratio	confidence interval
Mother literate	178	226	78.8	131	176	74.4	1.06	0.95-1.18
Mother not housewife*	146	188	77.7	158	207	76.3	1.02	0.91-1.13
Father education >junior high	152	184	82.6	157	218	72	1.15	1.03-1.28
Father employed	95	114	83.3	214	288	74.3	1.12	1.01-1.25
Eating > three sweets daily	208	272	76.5	101	130	77.7	0.98	0.88-1.10
Daily consumption of tea	199	262	76.0	110	140	78.6	0.94	0.84-1.06
Drinking piped or tube well water	2	3	66.7	307	399	76.9	0.87	0.39-1.93
Television & radio in the household	245	310	79.0	65	92	70.7	1.11	0.96-1.28
Brushing teeth with a brush	286	372	76.9	23	30	76.7	1.00	0.82-1.23
Daily tooth brushing	250	320	78.1	59	82	72.0	1.09	0.94-1.26
Changing toothbrush every six month	106	136	77.9	203	266	763	1.02	0.91-1.14

* Mothers of 7 children had expired.

Table 4: Prevalence of caries among schoolchildren in plains, according to selected characteristics, Nainital district, Uttaranchal, India, 2004

Characteristics	Exposed			Unexposed			Prevalence ratio	95 % confidence interval
	#	Total	%	#	Total	%		
Mother literate	82	204	40.2	72	196	36.7	1.09	0.85-1.40
Mother not housewife*	67	183	36.6	86	214	40.2	0.91	0.71-1.17
Father education >junior high	72	176	40.9	82	224	36.6	1.06	0.82-1.36
Father employed	33	81	40.7	121	319	37.9	1.07	0.80-1.45
Eating > three sweets daily	112	297	37.7	42	103	40.8	0.92	0.70-1.22
Daily consumption of tea	138	349	39.5	16	51	31.4	1.2	0.76-1.82
Drinking piped or tube well water	131	362	36.2	23	38	60.5	0.6	0.45-0.80
Television & radio in the household	114	297	38.3	37	103	35.9	1.1	0.83-1.49
Brushing teeth with a brush	141	359	39.3	13	41	31.7	1.24	0.78-1.98
Daily tooth brushing	96	260	36.9	58	140	41.4	0.89	0.69-1.15
Changing toothbrush every six month**	38	96	39.6	106	268	39.6	1.00	0.75-1.33

* Mothers of 3 children had expired.

**36 children were not using tooth brush. Out of these 36 children 10 had dental caries and 26 were free of caries.

Table 5: Health care seeking behaviours in case of tooth pain among schoolchildren 12 years of age in plain (n=400) and hills (n=404), Nainital district, Uttaranchal, India, 2004

		No.	Prevalence (%)
Hills	No treatment	45	11
	Private hospital	60	15
	Quacks	3	1
	Government hospital	223	55
	Don't know	71	
Plains	No treatment	21	5
	Private hospital	41	10
	Quacks	17	4
	Government hospital	263	66
	Don't know	58	