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An investigation of the possible anti-cariogenic effect of raw sugarcane: an epidemiologic study of 12-year-old Punjabi Children, India

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A thesis submitted in partial fulfilment
of the requirements for the degree of

MASTER OF DENTAL SCIENCE
Community Oral Health and Epidemiology



Faculty of Dentistry
The University of Sydney Australia

2006

Dedication

*I dedicate my thesis to my father E.P. Harvatar Singh
and to my mother Surinder Kaur for their constant
support and courage to support me in studying further
and helping me financially and emotionally in
completing my degree.*

Acknowledgements

I would like to express my sincere thanks to the following people for their contribution and help towards the research and preparation of the thesis:

- Associate Professor Wendell Evans, Head of Discipline, Community Oral Health and Epidemiology, University of Sydney for his guidance and assistance in completing the thesis.
- Azad Singh, School Principal, for his support in conducting the survey.
- Dr Karen Byth, Statistician, for her help in conducting the statistical analysis.
- Dr Brad Curtis, PhD student, for his help with the literature search.
- Ms Ramona Grimm, Administrative Officer, Community Oral Health and Epidemiology for her administrative support.
- Dr Sarkis Nalbandian, Dentist, for his encouragement and emotional support during the completion of the thesis.
- Dr Abhinandan Vashistha, dental colleague, for his constant support and encouragement during the writing of the thesis.

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List of Abbreviations

DMFT	Decayed, missing, and filled teeth
DMFS	Decayed, missing, and filled surfaces
F	Fluoride
mg/L	Milligram per litre
OR	Odds Ratio
ppm	Parts per million
ml	millilitre

Foreword

This thesis is divided into two parts:

Part One: A review of the international literature on the relationship between sugarcane chewing and dental caries.

Part Two: Part two of this thesis is a paper that will be submitted for publication in *Community Dentistry and Oral Epidemiology* concerned with an epidemiologic study of 12-year-old Punjabi school children, India. The purpose of this study was to investigate the effect of raw sugarcane on caries experience. It was a parallel study of 12-year-olds residing in (1) the sugarcane belt and in (2) a non-sugarcane growing area of the Amritsar District in the Punjab, India.

Part One:
Review of Literature

Review of Literature

In vitro studies

The first of the studies on sugarcane and dental caries were conducted by Osborn *et al.* (1937). They incubated healthy human teeth at 37⁰C with a mixture of saliva and crude sugarcane juice (15% sucrose) or with saliva and refined pure sugar juice (15% sucrose). The mixtures were renewed daily and were agitated continuously by means of bubblers. After 2-8 weeks of this treatment it was found that of 32 teeth exposed to the saliva-refined sugar mixture, 15 became decalcified, whereas only 3 of 32 teeth became decalcified by the saliva-crude sugarcane juice preparation. They concluded that, at least under those in vitro conditions, the raw sugarcane juice must have protective effect against the development of caries.

Jenkins *et al.* (1959) conducted *in vitro* studies on crude and refined sugars to determine the influence of the refinement of carbohydrates on their cariogenicity. Pure sucrose and crude cane juice were compared. In the procedure for incubation experiment 50 mg calcium phosphate mixed with 7 ml saliva was added to each of 5 ml of (a) Sugarcane juice (20% sucrose) (b) pure sucrose solution (20% sucrose). After incubation for 24 hours, the concentration of phosphate in solutions (a) and (b) increased by 9 and 79 micrograms/ml, respectively. The protection of teeth was clearly seen by visual inspection as well as by chemical analysis.

Cross-sectional uncontrolled studies

In the study conducted by Samuel Dreizen *et al.* (1952) in west central Cuba. Dental decay was investigated in a group of subjects who were originally from that region and chewed sugarcane daily, and also consumed raw sugarcane juice in large quantities daily, especially in harvesting season. Daily diet since birth was high in natural and unrefined carbohydrate foods. Crude brown sugar was used exclusively for seasoning and cooking. Of the 147 total number of subjects chosen, only 10 were edentulous and 137 had a complete or partial natural dentition. The DMFT score was 15.1. Only one person was caries free. Extensive amounts of tooth destruction and high caries incidence in the group did not support their null hypothesis "that raw sugarcane and unrefined carbohydrates contain a protective factor in amounts sufficient to prevent tooth decay".

In another study, conducted by Harris and Cleaton-Jones (1978) on 98 Bantu sugarcane chewers in South Africa, the rural labourers lived and worked in sugarcane farms in the Pongola district. All ate a typical Bantu diet consisting of maize meal supplemented by legumes and meat. Fluoride level in drinking water was <0.1 ppm. On average 4-5 kg of sugarcane was chewed per day (=500g sucrose), however the mean DMFT scores for adolescents, young adults, middle, and old age groups were: 0.9, 3.1, 6.0, and 8.1, respectively. The mean DMFT across all age groups in this male population was 2.8.

Nörmark and Mosha (1989) conducted a study to investigate the relationship between habits and dental health among rural Tanzanian children. A total of

399 children of standard two were examined average age was 10.9 yrs. Fifty-three percent of children examined were caries free. Seventy-three percent of the caries observed were in occlusal surfaces of molars. No fillings were present and no teeth were missing due to caries. Fifty-nine percent of children ate sugarcane everyday. Children eating cakes, biscuits, and /or sweets at least three times a day seemed to have more caries than the children who did not, their DMFS being 1.5 and 1.1 respectively. The distribution of DMFS by sugarcane was random. They concluded that "consumption of sugarcane did not bear any relation to the caries experience".

Rugarabamu *et al.* (1990) assessed caries experience in 12 and 15-year-old children living on a sugar estate in Kilombero, Tanzania. The average sugar consumption per capita per year was estimated to be six times higher (35kg v/s 6kg) for the estate population than for the Tanzanian population as a whole. At that time, refined sugar was regarded as a "very precious commodity" because not everyone had easy access to it. However, sugar plant workers were given a 10kg bag of sugar per month as an incentive. (It cannot be assumed however, that they consumed the total sugar given to them because it was reported that it may have been given to friends or relatives). The fluoride concentration level in the area varied between 0.23 - 0.27 ppm (dry season) and 0.57 - 0.65 ppm (wet season). The percentage of caries-free children was higher in 12- year olds (68%) than in 15- year olds (60%). Compared with the mean DMFT score of 0.48 in this study for 12-year-old children, similar DMFT scores of 0.51 and 0.67 for rural and urban 12-year-olds, respectively, have been reported in relation to other communities

investigated in Tanzania by the same authors (Manji *et al.*, 1988; Frencken *et al.*, 1986). It might have been expected that the caries experience of the children in the sugarcane estate would be higher than elsewhere due to their much higher consumption of refined sugar. However, the results supported the author's (Rugarabamu) conclusion that the caries experience of children in the sugarcane estate was low and in keeping with data elsewhere in Tanzania. Nevertheless, it cannot be overlooked that the caries experience of the estate children was low because of the possible caries protective effect afforded by sugarcane consumption.

Cross-sectional controlled study

Frencken and Rugarabamu (1989) conducted a study to investigate the effect of sugar cane chewing on the development of dental caries in Tanzania. Two groups, 77 sugar cane cutters and 68 sisal workers, were compared. The daily mean numbers of sugarcane pinglee (sections of a sugarcane stick) consumed by the cane cutters and sisal workers were estimated to be 8.1 and 0.8 respectively. It was claimed that the diets of the two groups were otherwise comparable and that the both groups consumed around 4 gm of refined sugar per day. Socio-economic status and fluoride levels in drinking water in both the groups were similar. The caries experience of the sugarcane cutters and sisal workers were 3.5 and 2.0 DMFT ($p=0.01$) and 13.9 and 7.8 DMFS ($p=0.02$) respectively. Greater pinglee consumption was associated with higher mean DMFS ($p=0.05$) and DMFT ($p=0.02$) scores. The authors concluded that the data "suggest that sugar cane chewing in large quantities

over a long period of time has caries-promoting effecting a population with low caries prevalence".

Controlled cohort study

Harris *et al.* (1967) conducted a clinical trial of 5-17 year old boarding school children in Queensland, Australia. Two groups, 361 controls and 166 treatments were compared. The treatment group was exposed to a diet in which calcium sucrose phosphate was substituted for dietary sugar. Both the groups were followed for a period of 3 years. Medical investigation showed no differences in the physical status and general health between the children of both groups. Compared with children in the control groups, scores for DMFT, DMFS, and DMFS (proximal surfaces) for 9-13 year old children were less by 15.3%, 17.9%, and 29.5%, respectively in the group in which calcium sucrose phosphate was substituted for dietary sugar.

Experimental cross over study

Fejerskov (1992) conducted a study on five rural Kenyan children aged 7 to 14 years, to investigate the effect of sugar cane chewing on plaque pH. The selected children had poor oral hygiene and had two or more open carious cavities. The children were asked to rinse with 10ml of 10% sucrose solution on day 1 and to chew sugarcane for 3 min on day 2. Each day, the plaque pH measurements were taken before the experiment (the resting pH) and at 2, 5, 10, 15, 20, and 30 mins after rinsing or chewing. pH responses were measured at interproximal sites in the maxilla and the mandible. The main results were that following sugarcane chewing, plaque pH dropped and then

recovered to resting values in 5-10 mins or before, at all sites, whereas, pH values took longer than 30 minutes to recover following the sucrose rinses. It was concluded that the result was probably not due to a protective factor derived from the sugarcane but that the rapid pH rise was a natural result of an increased saliva flow rate which, in this case, was stimulated by the combination of the sweet cane juice and the vigorous chewing action required to masticate the tough cane.

Review of findings

The analysis of the literature summarized in Part One of this thesis is reported on in the introduction section in Part Two.

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Part Two:

The cariogenicity of raw sugarcane – a study of Punjabi 12-year-olds, India

The cariogenicity of raw sugarcane – a study of Punjabi 12-year-olds, India

A SINGH, R.W.EVANS.

Abstract

Introduction: There is laboratory evidence that compared with unrefined carbohydrates, refined carbohydrates are more cariogenic. It was reported that sugarcane workers in South Africa, who consumed large quantities of raw sugarcane daily, had a low caries experience. However, other epidemiologic studies of this relationship both in Africa and elsewhere have given mixed results and to date the question concerning the cariogenicity of raw sugarcane remains equivocal.

Objective: The purpose of the present study was to investigate further the hypothesis that children who reside in a sugarcane growing region will have a lower caries experience than those residing in an otherwise comparable environment outside of the cane growing region.

Material and methods: A total of 404 Children aged 12 years were selected from government schools in both sugarcane and non-sugarcane regions of Amritsar district in the state of Punjab, India. The drinking water in both regions contained fluoride at 0.5 ppm. Data on eating habits of the children were obtained by questionnaire and caries experience was determined during a clinical examination. Informed consent for the survey was obtained from the parents of the children.

Results: The mean DMFT scores for the sugarcane and non-sugarcane groups were 0.41 and 0.70 respectively ($p < 0.002$). Neither the potential confounding variables of lollie consumption, dietary added sugar, and mealtime consumption of sugar-containing beverages were significantly associated with caries experience.

Conclusion: The null-hypothesis is rejected; the results of this study support the hypothesis that the chewing of raw sugarcane is associated with reduced dental caries.

To be submitted for publication in Community Dentistry and Oral Epidemiology.

Introduction

On the basis of an examination of skulls dating from the bronze-age onwards, Hardwick demonstrated that dental caries was rare in England and that its prevalence fluctuated with rises and falls in cereal production (1). Lesions were confined mainly to cervical margins whereas coronal caries did not generally occur until sugar came into common usage in the 17th century. Several 20th century studies of remote hunting communities have detailed dramatic rises in caries experience coinciding with diet changes following a sudden exposure to flour and sugar containing foodstuffs (2, 3).

Prior to the development of an understanding of the role of fluoride in caries prevention, research centred on the diet-caries relationship which indicated that the upsurge in sugar consumption was mainly responsible for the caries pandemic that swept western cultures during the first half of the 20th century (4). The acid theory regarding the etiology of dental caries was first postulated by Miller (1890) who demonstrated that when extracted teeth were incubated in a mixture of saliva and carbohydrate, they were subject to demineralization (5). In 1937, Osborne and Noriskin (6) reported on the low caries experience of cane cutters in South Africa in a region where the fluoride concentration in the drinking water was less than 0.1 mg/L. These workers chewed up several sugarcane sticks daily and consumed large quantities of sugarcane juice. On average, workers consumed 4.5kg of sugarcane daily (500gm sucrose) (7). Osborn *et al.* (8) demonstrated via *in vitro* studies that the incubation of mixtures of saliva and pure sucrose readily results in the

production of organic acids and that the addition of teeth or calcium phosphate to these mixtures results in their dissolution. On the other hand, when such experiments are repeated in which pure sucrose is replaced with raw sugarcane juice, the dissolution does not occur despite the acidic environment. As a result, it was postulated that phosphates which are removed during the sugar refining process, are protective against dental caries (9). It was later shown that, in fact, the acid yield on fermentation of unrefined carbohydrate was about double that derived from the refined products (10).

Animal studies demonstrate that dietary phosphate additives are protective against experimentally induced caries (11), but epidemiologic studies of caries experience in sugarcane chewers (see Table 1 for summary), that have been cited in discussions of the hypothesis that consumption of raw sugarcane is protective against caries, give mixed results (12).

Possible support for a protective effect was reported more recently among 100 Tanzanian 12-year-olds living on a sugarcane estate (13). Caries experience there was reported to be similar to that of other rural and urban Tanzanian children examined by the same authors (14, 15), but it was also reported that workers at the sugarcane estate received refined sugar as a work incentive, and that refined sugar consumption by the estate population was six times the national average. Had it not been for the possible protective effect of the sugarcane, it might have been expected that the caries

Table 1. Summary of studies investigating the possible anticariogenic effect of raw sugarcane chewing.

First author	Study type	Location	Method and results	Support ¹	Comment
Osborn (7)	In vitro	South Africa	32 teeth were added to each of mixtures of saliva and (a) crude sugarcane juice (15% sucrose) and (b) refined pure sugar solution (15% sucrose). After 8 weeks incubation, 3 and 15 teeth in solutions (a) and (b) respectively were decalcified	Yes	
Driesen (18)	Cross sectional	Cuba	Study of 147 sugarcane cutters who chewed and drank large quantities of sugarcane juice daily. Crude brown sugar was also used extensively in cooking and for food seasoning. Mean DMFT was 15.1, 10 were edentulous, and 1 was caries free.	No	No control for non-cane cutters and other sugar use
Jenkins (22)	In vitro	United Kingdom	50 mg calcium phosphate mixed with 7 ml saliva was added to each of 5 mls of (a) sugarcane juice (20% sucrose) and (b) pure sucrose solution (20% sucrose). After incubation for 24 hours, the concentration of phosphate in solutions (a) and (b) increased by 9 and 79 micrograms/ml, respectively.	Yes	
Harris R (15)	Controlled cohort	Australia	Boarding school children aged 9-13 years were exposed to (a) diet in which calcium sucrose phosphate was substituted for dietary sugar and (b) normal diet. Compared with children on diet (b) scores for DMFT, DMFS, and DMFS (proximal surfaces) were less by 15.3%, 17.9% and 29.5%, respectively.	Yes	
Harris S (6)	Cross sectional	South Africa	Study of 98 male and female sugarcane chewers aged 14-60 years. Their daily mean consumption of sugarcane was 4.5kg (500gm sucrose). Normal diet comprised maize, legumes, meat, and water (< 0.1 ppm F). DMFT scores for adolescents, young adults, middle and old age groups were: 0.9, 3.1, 6.0, and 8.1, respectively.	Yes	High intake of sucrose and low caries experience hints at protective effect.
Nörmark (19)	Cross sectional	Tanzania	Study of 399 children aged 7-15 years. The distribution of DMFS by sugarcane was random	No	No control for age.
Freuchen (20)	Cross sectional controlled	Tanzania	Study of (a) 77 sugarcane cutters and (b) 68 sisal labourers. Diets, said to be comparable, included 4gm of refined sugar daily. The ratio of daily sugarcane eaten (a):(b) was 8.1:0.8. DMFS for (a) and (b) were 13.9 and 7.8, respectively.	No	
Rugarambu (12)	Cross sectional	Tanzania	Study of 100 sugarcane estate children aged 12 years, where estate consumption of refined sugar was 6 times higher than the national average. Mean DMFT of 0.48 was comparable to scores of 0.51 and 0.67 for other rural and urban 12-year-olds, respectively.	Possible	Sugarcane chewing may have counter-acted the effect of exposure to refined sugar.
Fejerskov (17)	Experimental cross over	Kenya	Study of children aged 7-14 years with 2 or more open cavities. On day 1, they rinsed with 10% sucrose solution, and on day 2, chewed sugar cane for 3 minutes. Plaque pH was measured at non-carious proximal sites before and up to 30 minutes following both rinsing and chewing. After rinsing with sucrose solution, pH values recovered after 30 minutes, but fell less and recovered in 5-10 minutes following chewing sugarcane.	Yes	

¹Support for hypothesis that raw sugarcane chewing is anticariogenic.

experience of the estate children would be higher than among the children from elsewhere.

Strong support for a sugarcane-related protective effect was shown in Australia (16) where a controlled cohort study was conducted among 399 boarding school children to investigate the effect of supplementing dietary sugar with calcium sucrose phosphate, the organic phosphate which is presumed to be removed from sugarcane during the refining process.

Children attending the control schools followed their usual diet while those belonging to the experimental group were exposed to a diet in which the added sugar was supplemented with calcium sucrose phosphate. After three years, the DMFT, DMFS, and DMFS (proximal surfaces) were 15.3, 17.9, and 29.5% less in the experimental children aged 9-13 years compared with the control children of the same age. While these results seem impressive, Craig (17) reported that during the course of the study, the groups became unbalanced and that the results could be biased. A more recent *in vivo* study of Kenyan children, aged 7-14 years, with cavitated teeth confirmed the anti-cariogenic potential of chewing sugarcane (18). On one day, they rinsed with 10% pure sucrose and on the next day they chewed sugarcane for 3 minutes. Measurements at interproximal sites on both days showed that pH falls following sucrose rinses were deeper than those following the chewing of sugarcane. Further, the depressed pH induced by the sucrose exposure took longer than 30 minutes to return to baseline levels compared with return times of 5-10 minutes following sugarcane chewing. It was concluded that the result was probably not due to a protective factor derived from the sugarcane but

that the rapid pH rise was a natural result of an increased saliva flow rate which, in this case, was stimulated by the combination of the sweet sugarcane juice and the vigorous chewing action required to masticate the tough cane.

On the other hand, in Cuba (19), where brown sugar is used extensively in cooking and for food seasoning, extensive caries experience and tooth loss was reported among sugarcane workers. This study did not, however, include non-sugarcane eating controls, nor was the dietary added sugar controlled for. The results of another cross sectional study of sugarcane consumption among Tanzanian children aged 7 to 15 years failed to demonstrate a correlation with caries experience, however it is not clear whether either age-related consumption of sugarcane or age-related caries experience was controlled for in this study (20). In a controlled cross sectional study of adults, also conducted in Tanzania, a caries protective effect among 77 cane cutters was not evident (21). In this study, the caries experience of 68 sisal labourers was also investigated. Although the ratio of sugarcane consumption by the cane cutters and the sisal labourers was 10:1, the diets of both groups were otherwise said to be comparable and low in refined carbohydrates. The respective mean DMFS scores of the sugarcane and sisal workers were 13.9 and 7.8.

The purpose of the present study was to investigate further the hypothesis that children who reside in a sugarcane-growing region will have a lower caries experience than those residing in an otherwise comparable environment outside of the cane-growing region.

Material and methods

This survey of 12-year-old children attending government schools was conducted in the Amritsar District of the State of Punjab, India. They were selected from villages surrounding a sugar mill, close to the town of Mehta in the sugarcane belt along the Beas River. Sugarcane chewing occurs during two periods each year totalling about 6 months when the cane is harvested. Parents of children attending the largest seven village schools in this area were requested to give permission for their 12-year-olds to participate. Similarly, consent was obtained from parents of the reference children who attended the six largest schools in villages around Attari, a non-sugarcane growing region. Attari is a small town, 50 km southwest of Mehta, near the border with Pakistan. In both areas, the fluoride concentration in the drinking water was less than 0.5 mg/L. Families subsist on their land from one generation to the next, so that the children examined were life-long residents of their respective areas. Although the children in both regions were either Sikhs (the majority) or Hindus, they live in rural villages and share the same cultural beliefs and practises; in particular, their diets are the same. Only government schools were selected, and only children of lower socio-economic groups attend government schools in Punjab.

At the selected schools, the children were interviewed according to a structured questionnaire to obtain information on their diet and tooth brushing habits. This was followed by a clinical examination. These were conducted outside in natural daylight by a single examiner (AS) who had been calibrated

before the survey. The children, none of whom had experienced previous dental care, were seated on a chair and their teeth were examined with the aid of a wooden spatula but without drying. Caries was diagnosed by visual inspection alone whereby teeth were recorded as decayed on the evidence of presence of cavitation (22). The data were later entered into an electronic database for subsequent statistical analysis.

Intra-examiner calibration was carried out during return visits to two schools in each region where randomly selected children were re-examined under the same conditions as previously.

Following data checking, the mean DMFT scores of children in the two locations were calculated and compared. The effect of potential confounding variables on the relationship between residential location and dental caries experience was conducted. Firstly, the univariate association of each of the potential confounders (total added dietary sugar, lollie consumption, mealtime consumption of sugar containing beverages, tooth brushing frequency, and use of fluoridated toothpaste) with DMFT was assessed. Secondly, the potential confounders that were shown to be significantly associated with differences in DMFT were included in a multiple variable regression analysis. As the data were highly skewed (the majority of the children were caries free) a logistic regression model (caries experience was dichotomised as DMFT = 0 or 1+) was developed using the backward stepwise selection option. The analyses were carried out using SAS statistical software, Release 8.2.

Results

A total of 404 12-year-olds participated in the study. The children living in the sugarcane belt chewed around three to four sticks of sugarcane daily during the cane harvesting seasons. None of the children had received dental care. The DMFT scores reflected decayed or missing teeth only. Caries experience in both the sugarcane and non-sugarcane groups, which was confined almost exclusively to the first permanent molars, is presented in Table 2. The mean DMFT of the non-sugarcane group was 0.70 (sd=1.17) compared with 0.41 (sd=0.96) in sugarcane group. That is, the mean DMFT was 71% higher in non-sugarcane group and further, the proportion of children who had one or more DMFT was 62% higher in the non-sugarcane group. The kappa value relating to diagnostic reliability, based on 51 duplicate examinations, was 0.73.

The distribution of mealtime risk factors for caries experience, namely sugar containing beverages, which are consumed at breakfast, tiffin (lunch), and dinnertime, is shown in Table 3. Except for yoghurt (12% versus 3.9%), the consumption of all other sugar containing beverages was greater in the sugarcane group than in the non-sugarcane group at breakfast ($p<0.001$). At tiffin (lunch), more milk with added-sugar was consumed by the non-sugarcane group (43% versus 19%) and at dinnertime, more sweetened tea was consumed by non-sugarcane group (56% versus 27.5%) ($p<0.001$).

Table 2. Caries experience by residential area.

	n	Mean DMFT	(sd)	DMFT = 0		DMFT = 1+		p-value*
				n	%	n	%	
Non-sugarcane	200	0.70	1.17	127	63.5	73	36.5	0.002
Sugarcane	204	0.41	0.96	158	77.5	46	22.5	

*Chi-square = 9.45, DF = 1

Table 3. Mealtime intake of water and sugar-containing beverages

Meal	Sugarcane group	Water		Milk		Tea		Yoghurt		Total	p-value*
		n	%	n	%	n	%	n	%		
Breakfast	Non-sugarcane	84	42.0	5	2.5	87	43.5	24	12.0	200	<0.001
	Sugarcane	78	38.2	22	10.8	96	47.1	8	3.9	204	
Tiffin	Non-sugarcane	21	10.5	86	43.0	86	43.0	7	3.5	200	<0.001
	Sugarcane	56	27.5	39	19.1	102	50.0	7	3.4	204	
Dinner	Non-sugarcane	32	16.0	32	16.0	112	56.0	24	12.0	200	<0.001
	Sugarcane	56	27.5	25	12.3	56	27.5	67	32.8	204	

*Chi-square (across milk, tea, and yoghurt), DF = 2

Table 4 shows the distribution of exposure to additional caries risk factors namely tooth brushing habits, lollie consumption, and total daily added-sugar to children in both groups. Both groups had almost identical tooth brushing habits regarding brushing frequency and use of fluoride toothpaste. One quarter of the children reported that they brushed daily and 60% reported that they used fluoridated toothpaste. More children in the non-sugarcane group (88% versus 70%) consumed 4 or more lollies per day than in the sugarcane group ($p < 0.001$). An almost identical amount of total daily added-sugar was consumed by both groups; the median amount was 8 teaspoons per day. This amount included sugar that is eaten by itself, as a sweet, directly after a meal. The mean DMFT scores are lower in sugarcane group in relation to each of the risk/protective factors.

In the multivariable logistic regression analysis of risk factors for a caries experience (Table 5), all but one of the factors were dropped from the model, leaving residence area alone as the sole significant predictor of experiencing one or more DMFT (see Appendix E for full details of the model). Compared with children in the reference group, the children residing in the sugarcane growing region were 49% less likely to have decayed teeth (OR=0.51; 95%CI= 0.33, 0.78)

Table 4. Exposure of the children to protective/risk factors for dental caries and their caries experience by residence location.

Risk/protective factor	Exposure	Sugarcane		Non-sugarcane		p value	Mean DMFT (SD)		p value		
		n	%	n	%		Sugarcane	Non-sugarcane			
Toothbrushing frequency	Daily	54	26.5	53	26.5	0.916	0.48	(1.04)	0.77	(1.14)	0.168
	Weekly	150	73.5	147	73.5		0.39	(0.93)	0.67	(1.19)	0.021
Toothpaste use	Fluoride	116	56.5	119	59.5	0.590	0.45	(1.04)	0.53	(0.84)	0.601
	Non-fluoride	88	43.1	81	40.5		0.38	(0.91)	0.82	(1.35)	0.004
Lollies	2 per day	64	30.0	23	12.0	<0.001	0.39	(0.95)	0.65	(1.15)	0.280
	4 per day	140	70.0	177	88.0		0.42	(0.97)	0.71	(1.18)	0.021
Total daily added sugar (number of teaspoons)	0 - 4	21	10.3	12	6.00	0.383	0.28	(0.64)	0.58	(0.80)	0.249
	5 - 6	42	20.6	45	22.5		0.55	(0.83)	0.57	(1.03)	0.881
	7 - 8	79	38.7	74	37.0		0.38	(1.04)	0.73	(1.39)	0.078
	9+	62	30.4	69	34.5		0.40	(1.03)	0.77	(1.07)	0.049

Table 5. Odds ratio from best fitting* multiple variable logistic regression model (using the backward stepwise selection method) of risk factors for dental caries.

Explanatory variable	Variable category	Odds ratio	95% CI	p value
Residence	Sugarcane area	0.507	0.327, 0.784	0.0023
	Non-sugarcane area (reference category)			

* The effects of sugar consumption at breakfast, tiffin (lunch) and dinner, and the effect of lollie consumption were dismissed during successive steps ($p > 0.05$).

Discussion

Although overall caries experience of children in both regions was low, a clear cut association between exposure to raw sugarcane and caries experience was evident. The important question is: whether or not this association is causal. In this cross-sectional study, the caries experience outcome was measured directly on the day of the survey, while exposures to the variables of interest were inferred on the basis of the current habits of the children. The weakness of this research design is the assumption that measures of exposure, based on current habits, may be biased estimates of previous habits. Hence, the inference we have drawn on the basis of the exposure estimate can only be interpreted as suggestive of a causal link, rather than proof of one. To prove causation, the ideal research design would be that of a controlled cohort study in which children would be followed for a period, throughout which their exposure to sugarcane and relevant confounding factors, would be assessed at regular intervals. In this way, the exposures could be better quantified.

The explanation of the effect of sugarcane on caries incidence is problematic. Both organic and inorganic phosphates have been investigated in this regard. A review of more than 100 experiments showed conclusively that the addition of inorganic phosphates to cariogenic diets reduced the caries experience in animals (23). However, in a human clinical trial in which sweets supplemented with dicalcium phosphate were provided to school children over a three year period, no reduction in caries incidence was observed (24). The potential

effect of the organic phosphate, calcium sucrose phosphate, already referred to, is to raise both calcium and phosphate levels in plaque and saliva and its anti-cariogenic effectiveness is reportedly due to its ability to adsorb firmly to enamel surfaces and thus prevent its dissolution. In this regard, phytate, derived from unrefined cereals was identified as being more active than calcium sucrose phosphate (25). Wilson and Ashley (26) have reported on studies that have shown a strong relationship between levels of calcium and phosphate in plaque and caries incidence in adolescents. The increased concentration of calcium and phosphate in saliva reduces the likelihood of enamel dissolution as pH falls (27). However, more recently, in a 2-year cohort study of children aged 12 years, Pearce et al (28) demonstrated that while plaque calcium and phosphate were highly correlated with each other, when a set of confounding variables were taken into account, only calcium, and not phosphate, was significantly associated with a caries incidence of three or more DMFS.

On the other hand, the Indian diet is rich in milk, yoghurt, and cheese. In 1975, Rugg-Gunn reported that eating cheese after a sugar-containing snack raises plaque pH back to a safe level within 5 minutes (29). It has been proposed that this effect could be due to the stimulation of salivary flow which causes pH rise, or to the raising of calcium concentrations in plaque, or to increasing alkaline substances in plaque, or finally, due to the adsorption of a protective protein, such as casein, on the enamel surface, thereby physically slowing the dental caries process (29, 30).

In summary, the lower caries experience observed in the sugarcane group may be due to the protective effect of an organic phosphate, such as calcium sucrose phosphate, however, as already noted, the chewing of sugarcane stimulates saliva production, the rinsing effect of which reduces the potential for the sucrose to depress pH. The effect of chewing on saliva stimulation may be the protective factor, since the pH fall associated with the use of sucrose-sweetened chewing gum is neither deep nor long lasting as compared with the fall which follows a sucrose exposure alone (31).

A low caries experience was observed in both groups of children, despite their very high consumption of added sugar; sugar which is added, two spoonfuls at a time, to beverages including milk and yoghurt. In addition, for good measure, a spoonful of sugar is eaten by itself frequently, at the end of a meal. These observations indicate that our understanding of the relationship between caries and refined carbohydrates remains rudimentary.

Conclusion

It is concluded that the lower caries experience of Punjabi children, who chew large quantities of sugarcane daily during a period of about six months per year, is supportive of the hypothesis that raw sugarcane is associated with a caries protective effect. The protective factor may be intrinsic to the sugarcane such as an organic phosphate, or extrinsic, such as a saliva factor that is associated with vigorous chewing.

Acknowledgements

We are grateful to the school principals, parents, and children for their co-operation during the survey, and we thank the water engineers for data on the fluoride concentration in the water supplies in the survey regions. We are grateful to Dr Karen Byth for her advice on the statistical analysis.

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Appendices

Appendix A: Correspondence with the District Education Officer seeking permission for conducting the survey.

Appendix B: Letter of approval from the Human Research Ethics Committee, The University of Sydney, including, the Participant Information Sheet (English and Punjabi), the Parent/Guardian Consent Form (English and Punjabi), and the Need for Dental Care Form (English and Punjabi).

Appendix C: Clinical Examination Form.

Appendix D: Questionnaire (English and Punjabi).

Appendix E: Details of the multiple variable logistic regression analysis.

Appendix F: List of schools surveyed in both the sugarcane and the non-sugarcane growing areas.

Appendix G: Map of Amritsar (Punjab).

Appendix A.

Correspondence with the District Education Officer seeking permission for conducting the survey.

Wendell Evans, MDS DSc
Associate Professor
Community Oral Health and Epidemiology

Westmead Centre for Oral Health
Westmead Hospital
Australia NSW 2145

Tel: +61 2 9845 7537 Fax: +61 2 9845 8306
E-mail: w.evans@dentistry.usyd.edu.au

1 November 2004

The District Education Officer
Amritsar
Punjab
INDIA

Dear Sir

Proposed dental survey of 12-year-olds in Amritsar District

I am the director of the Master of Dental Science (MDS) program in the discipline of Community Oral Health and Epidemiology, Faculty of Dentistry, University of Sydney. Most candidates enrolled in this program are international students. During Year 2 of the MDS program, international students conduct a research project in their country of origin.

I have a student from India, Dr Amandeep Singh, who graduated in dentistry at the Magadh University, Bihar, and he is registered to practice dentistry with the Punjab Dental Council.

He is planning to conduct a research project in Amritsar District, Punjab. This will entail a dental survey of children aged 12 years attending schools in Amritsar District. The survey will comprise (1) a brief dental examination of the children which will be conducted according to World Health Organisation protocols, and (2) a short questionnaire to be completed by the children - this questionnaire will collect information on sugar intake including raw sugar cane chewing.

Altogether we plan to survey 200 children living in the sugar cane belt and 200 children living in other locations where there are no sugar cane plantations. It is anticipated that this survey will take place during the months of March and April 2005. Our plan is to survey children aged 12 years, however, for practical purposes it may be more convenient to survey whole school classes of children in which the majority of children would be aged 12, that is, we would examine children aged 11, 12, and 13.

I would be grateful if your advice on three matters. Firstly, what is the process for obtaining permission for Dr Singh to conduct this proposed survey. Secondly, what are the requirements in relation to obtaining consent from the school principals and the parents of the children. Thirdly, would you please advise the school grade or school class that would be likely to have mainly 12-year-olds.

Thank you for your help and I look forward to hearing from you shortly.

Yours faithfully,



Wendell Evans
Associate Professor

Office of District Education Officer (E/E) Amritsar

To

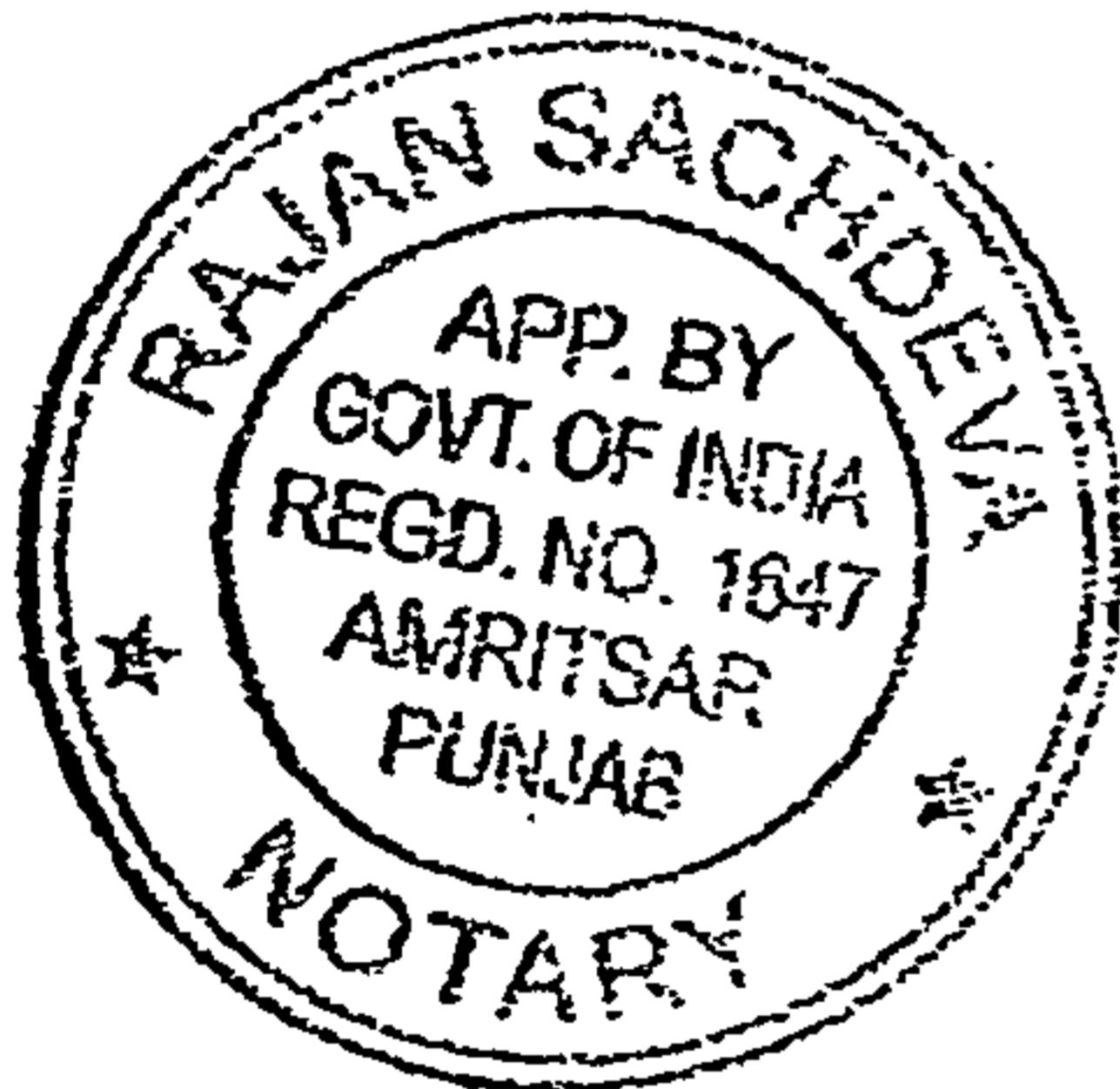
All Block Elementary Education Officer
District Amritsar

Letter No. G-1 / 2004 / 10055 to 82

Dated: 8-11-2004

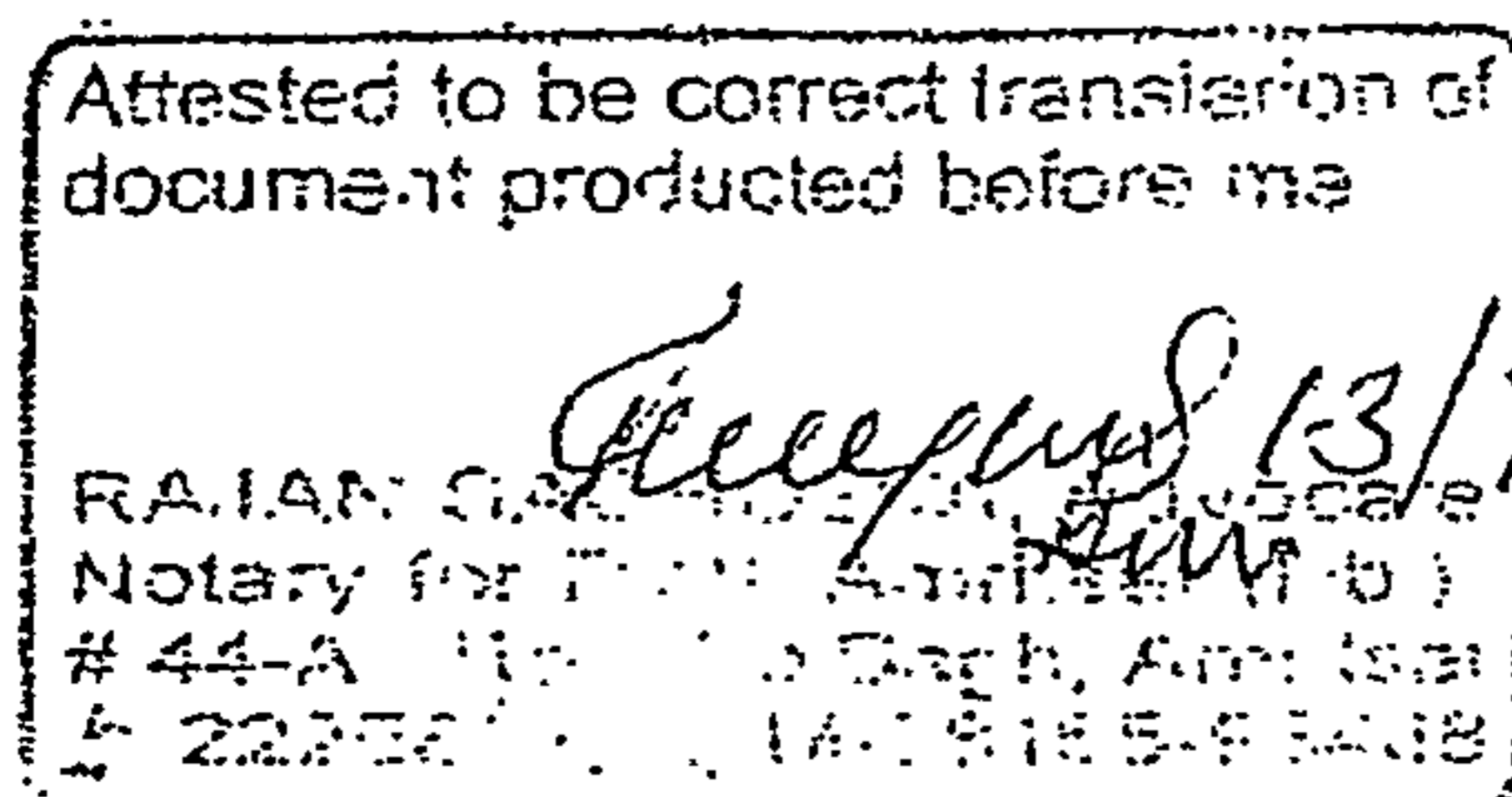
Subject: Regarding Dental Survey of Children in Amritsar District

Inform all School Heads that Dr. Amandeep Jee will visit there schools in connection with Dental Survey of Children's. Please extend full cooperation to him. Treat it as most urgent.



Sd/-
District Education Officer
Elementary Education
Amritsar

1. A copy of forwarded tp Wendell Evans, Associate Professor.
The University of Sydney, Australia
2. A copy is forwarded to Dr. Amandeep Singh, Westmead Center for Oral Health,
Wetmead Australia, NSW 2145



Sd/-
District Education Officer
Elementary Education
Amritsar

ਦਫਤਰ ਜਿਲਾ ਸਿਖਿਆ ਅਫਸਰ(ਐ:ਸਿ:) ਅੰਮ੍ਰਿਤਸਰ

=

ਵੱਲ

ਸਮੂਹ ਬਲਾਕ ਮੈਨੀਮੈਟਰੀ ਸਿਖਿਆ ਅਫਸਰ,
ਜਿਲਾ ਅੰਮ੍ਰਿਤਸਰ ।

ਪੱਤਰ ਨੰ: ਜੀ-1/2004-

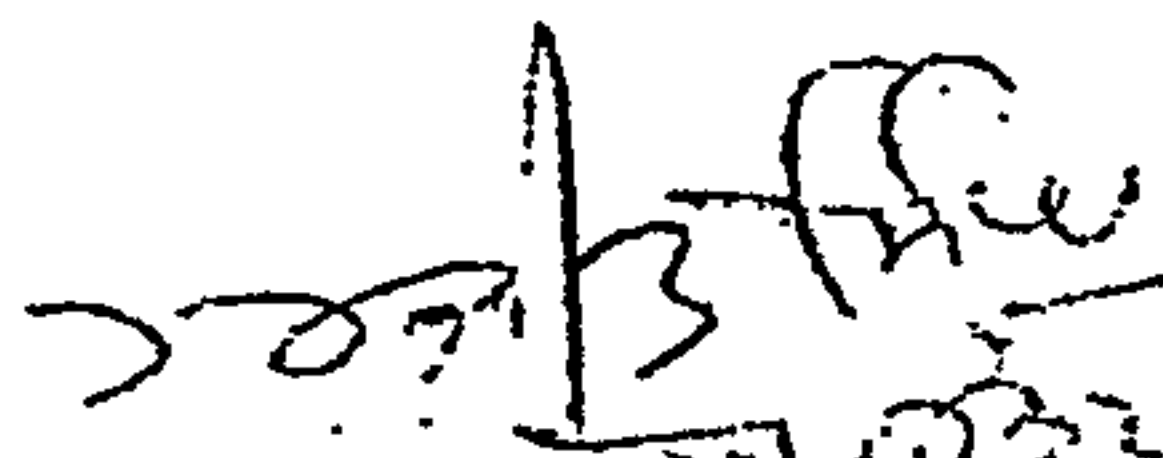
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ਮਿਤੀ:

8/11/04

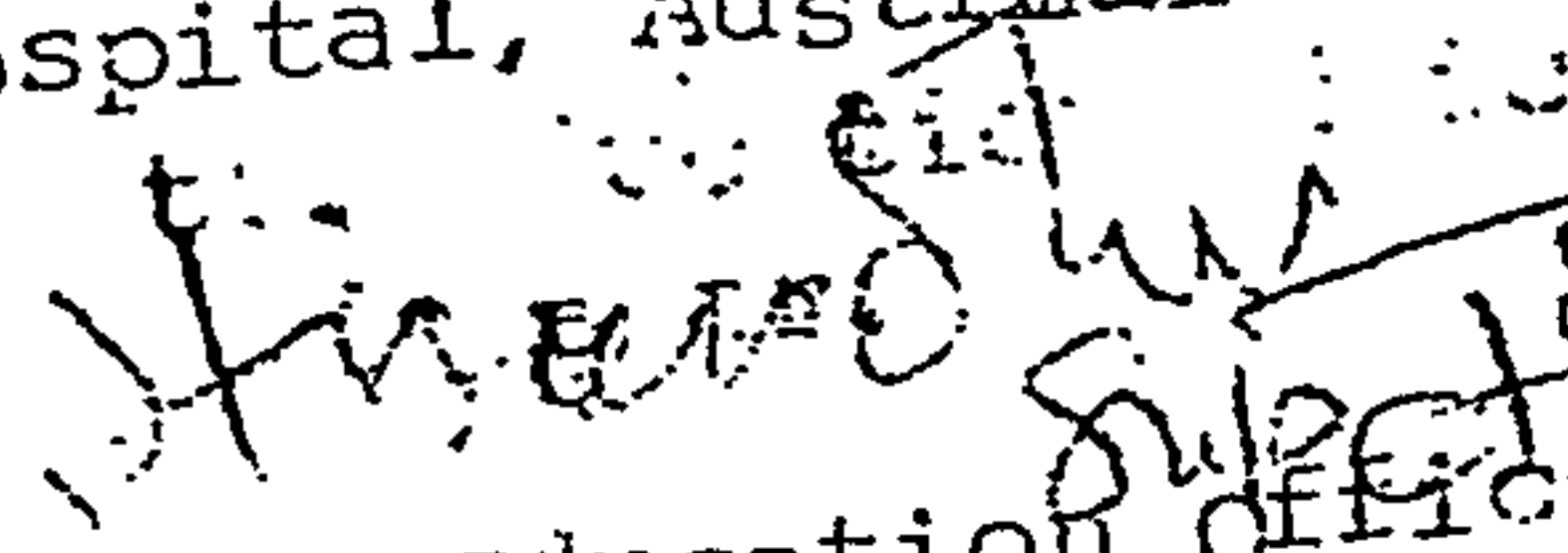
ਵਿਸ਼ਾ: ਅੰਮ੍ਰਿਤਸਰ ਜਿਲੇ ਵਿਚ ਬੱਚਿਆਂ ਦੇ ਦੰਦਾਂ ਦਾ ਸਰਵੇ ਕਰਨ ਬਾਰੇ ।

ਸਮੂਹ ਸਕੂਲਾਂ ਦੇ ਮੁੱਖੀਆਂ ਨੂੰ ਬੁਚਿਤ ਕਰ ਦਿੱਤਾ ਜਾਵੇ ਕਿ ਡਾ: ਅਮਨਦੀਪ ਸਿੰਘ ਜੀ ਉਹਨਾਂ ਪਾਸ ਬੱਚਿਆਂ ਦੇ ਦੰਦਾਂ ਦਾ ਸਰਵੇ ਕਰਨ ਸਬੰਧੀ ਜਾਣਕੀ । ਉਹਨਾਂ ਨੂੰ ਪੂਰਨ ਸਹਿਯੋਗ ਦਿੱਤਾ ਜਾਵੇ । ਇਸ ਨੂੰ ਅਤੀ ਜਰੂਰੀ ਸਮਝਿਆ ਜਾਵੇ ।


ਜਿਲਾ ਸਿਖਿਆ ਅਫਸਰ(ਐ:ਸਿ:) ਅੰਮ੍ਰਿਤਸਰ ।

A copy is forwarded to Wendell Evans, Associate Prof.
The University of Sydney, Australia.

2. A copy is forwarded to Dr. Amandeep Singh, Westmead
Centre for Oral Health, Westmead Hospital, Australia. NSW


Distt. Education Officer (E.E.)
Amritsar.

Appendix B.

Letter of approval from the Human Research Ethics Committee, The University of Sydney, including, the Participant Information Sheet (English and Punjabi), the Parent/Guardian Consent Form (English and Punjabi), and the Need for Dental Care Form (English and Punjabi).



The University of Sydney

NSW 2006 Australia

Human Research Ethics Committee
www.usyd.edu.au/ethics/human

Manager:

Gail Briody

Telephone: (02) 9351 4811

(02) 9351 4474

Facsimile: (02) 9351 6706

Email: gbriody@mail.usyd.edu.au

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Human Secretariat

Telephone: (02) 9036 9309

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Facsimile: (02) 9036 9310

Email: r.todd@reschols.usydedu.au

24 May 2005

Associate Professor W Evans
Community Oral Health and Epidemiology
Faculty of Dentistry
Westmead Centre for Oral Health
Westmead Hospital
C24

Dear Professor Evans

Thank you for your correspondence dated 29 April 2005 addressing comments made to you by the Committee. After considering the additional information, the Executive Committee approved your protocol entitled "*Dental survey of 12-year-olds in India*"

Details of the approval are as follows:

Ref No.:	05-2005/1/8029
Approval Period:	May 2005 – May 2006
Completion Date of Project:	31 December 2005
No. of Participants:	200 [per group]
Authorised Personnel:	Associate Professor W Evans Dr A Singh

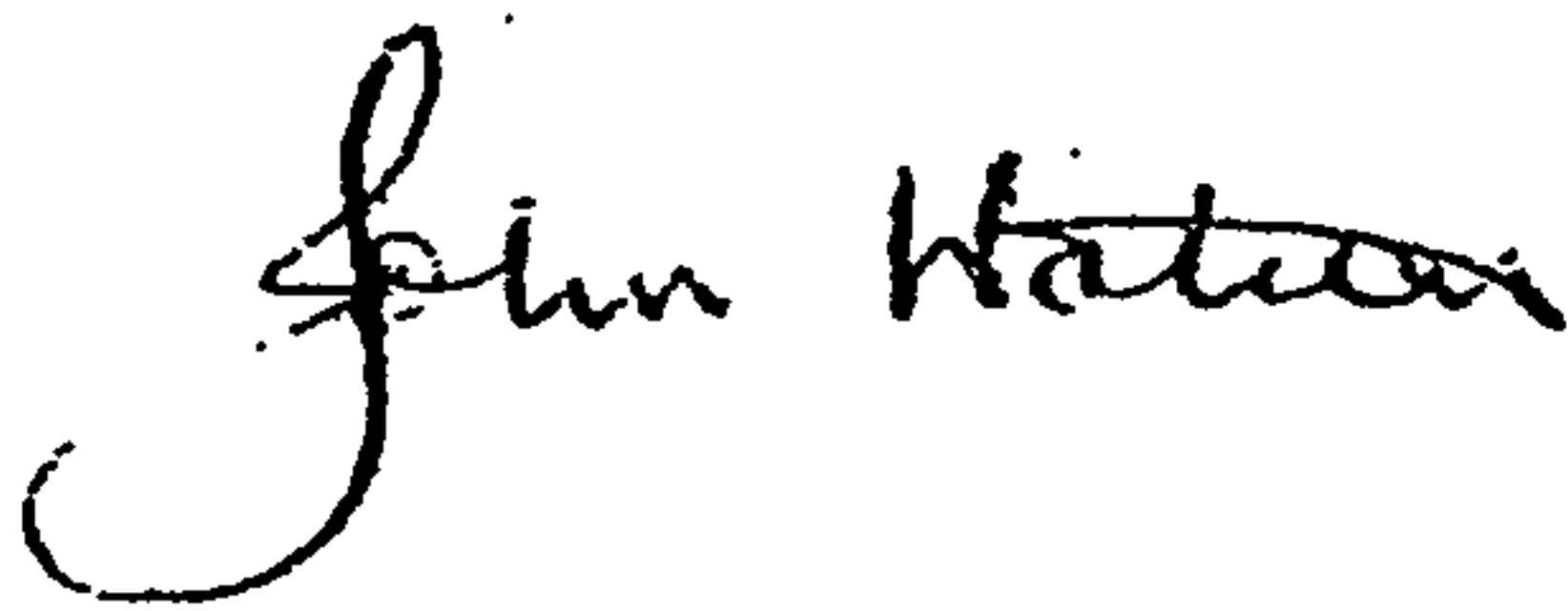
To comply with the *National Statement on Ethical Conduct in Research Involving Humans*, and in line with the Human Research Ethics Committee requirements this approval is for a 12-month period. At the end of the approval period, the HREC will approve extensions for a further 12-month, subject to a satisfactory annual report. The HREC will forward to you an Annual Progress Report form, at the end of each 12-month period. **Your first report will be due on 31 May 2006.**

Conditions of Approval Applicable to all Projects

- (1) Modifications to the protocol cannot proceed until such approval is obtained in writing. (Refer to the website www.usyd.edu.au/ethics/human under 'Forms and Guides' for a Modification Form).

- (2) The confidentiality and anonymity of all research subjects is maintained at all times, except as required by law.
- (3) All research subjects are provided with a Participant Information Sheet and Consent Form, unless otherwise agreed by the Committee.
- (4) The Participant Information Sheet and Consent Form are to be on University of Sydney letterhead and include the full title of the research project and telephone contacts for the researchers, unless otherwise agreed by the Committee.
- (5) The following statement must appear on the bottom of the Participant Information Sheet. ***Any person with concerns or complaints about the conduct of a research study can contact the Manager, Ethics Administration, University of Sydney, on (02) 9351 4811.***
- (6) The standard University policy concerning storage of data and tapes should be followed. While temporary storage of data or tapes at the researcher's home or an off-campus site is acceptable during the active transcription phase of the project, permanent storage should be at a secure, University controlled site for a minimum of seven years.
- (7) A report and a copy of any published material should be provided at the completion of the Project.

Yours sincerely



**Associate Professor J D Watson
Chairman
Human Research Ethics Committee**

Encl. Dear "Parent" letter
Participant Information Statement
Parent/Guardian Consent Form
Questionnaire



Dental survey of 12-year-olds

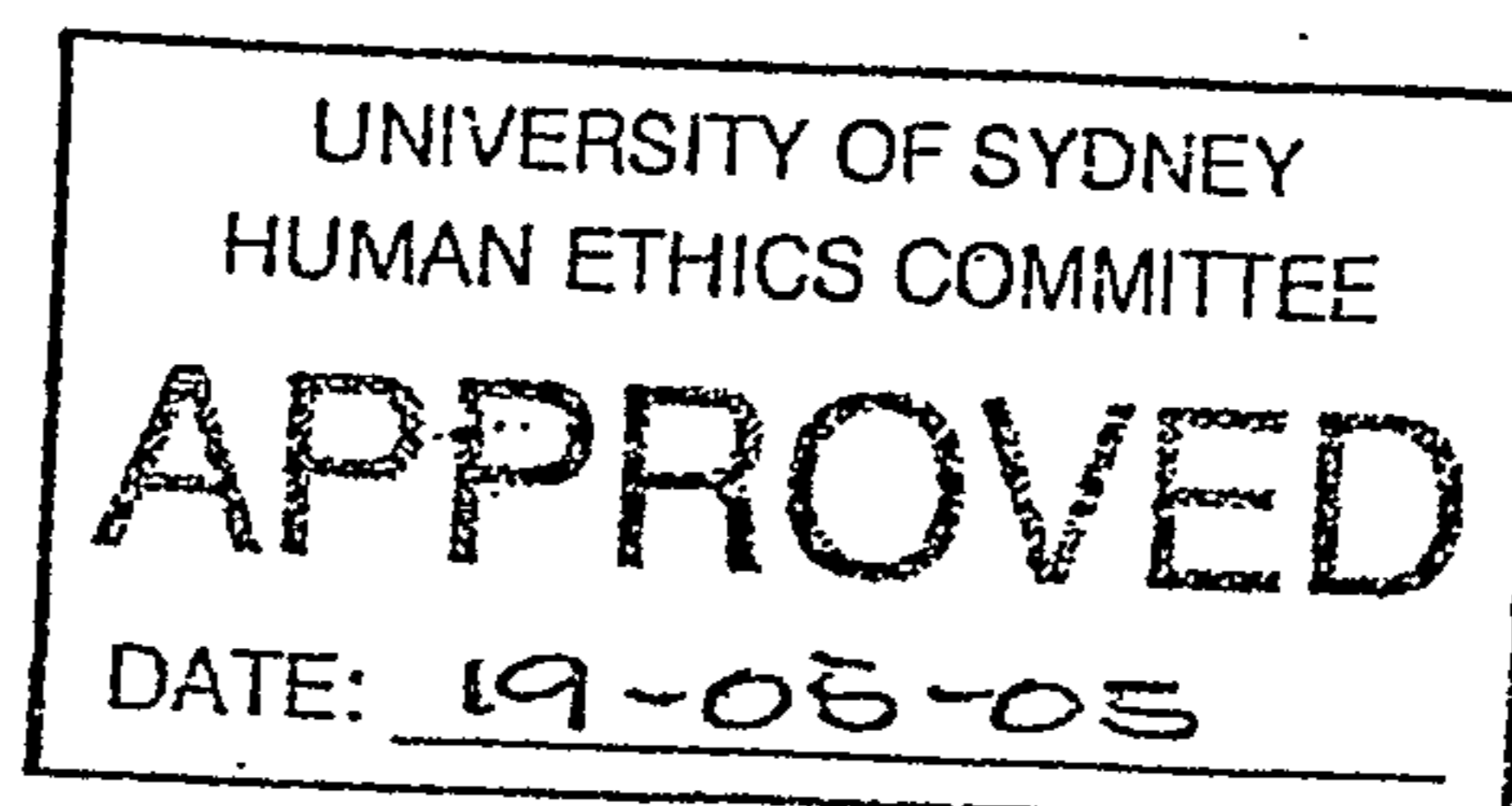
Need for dental care

Dear Parent,

I have examined your child today and wish to inform you that he/she needs to attend the dental clinic at for urgent treatment.

Sincerely,

DR Amandeep Singh
Dentist



ਸਿਡਨੀ ਯੂਨੀਵਰਸਿਟੀ

ਫੋਕਲਟੀ ਆਫ ਡੈਨਟਿਸਟਰੀ
ਕਾਲਜ ਆਫ ਹੇਲਥ ਸਾਇੰਸ

12 ਸਾਲ ਦੀ ਦੰਦਾਂ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਖੋਜ
ਦੰਦਾਂ ਦੀ ਸੰਭਾਲ ਬਾਰੇ

ਪਿਆਰੇ ਮਾਤਾ ਪਿਤਾ,

ਮੈਂ ਤੁਹਾਡੇ ਬੱਚੇ ਦਾ ਅੱਜ ਚੈਕ ਅਪ ਕੀਤਾ ਹੈ
ਅਤੇ ਤੁਹਾਨੂੰ ਦੱਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ ਕਿ ਉਸਨੂੰ ਦੰਦਾਂ ਦੇ ਕਲੀਨਿਕ
..... ਵਿਚ ਜ਼ਰੂਰੀ ਇਲਾਜ ਵਾਸਤੇ ਦਾਖਲਾ ਜ਼ਰੂਰੀ ਹੈ।

ਆਪ ਜੀ ਦਾ ਸੁਭਚਿੰਤਕ

ਡਾ ਅਮਨਦੀਪ ਸਿੰਘ
ਡੈਨਟਿਸਟ

Attested to be true copy of English version

Wing
Sub Divisional Engineer,
Pb. W/S & Sew. S/Divn-8.



Dental survey of 12-year-olds

Participant Information Statement

1. What is this study about?

Sugar that is added to food and drinks causes tooth decay. However, it is not certain that natural sugar in food and in sugar cane causes tooth decay. This study will check on tooth decay in 12-year-olds and find out if eating sugar cane causes tooth decay.

2. Who is carrying out the study?

This study is been conducted by DR. Amandeep Singh who is an Indian dentist and now training to be a dental specialist. His training is supervised by Associate Professor Wendell Evans at the University of Sydney, Australia.

3. What does the study involve?

This study involves a dental examination of your child conducted according to proper standards. DR Singh will also ask questions about your child's sugar eating habits.

4. How much time will the study take?

It will take not more then 5 minutes to complete everything.

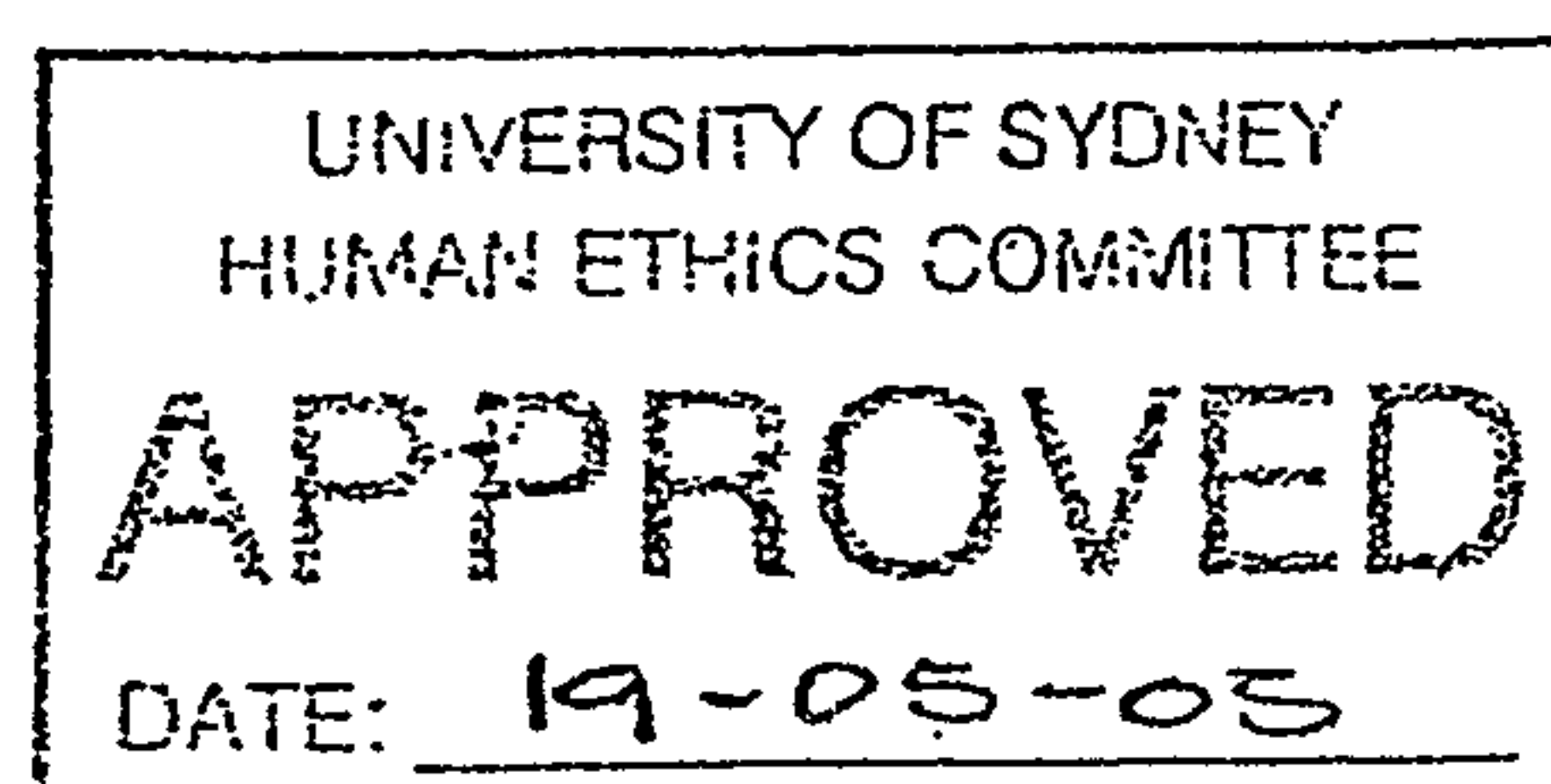
5. Can I withdraw from study?

Yes, you can withdraw anytime during study without penalty.

6. What if I require further information?

Please contact Dr. Amandeep Singh by telephone (9814129121) or by mail at House No 235 Sector 7 Panchkula, Haryana.

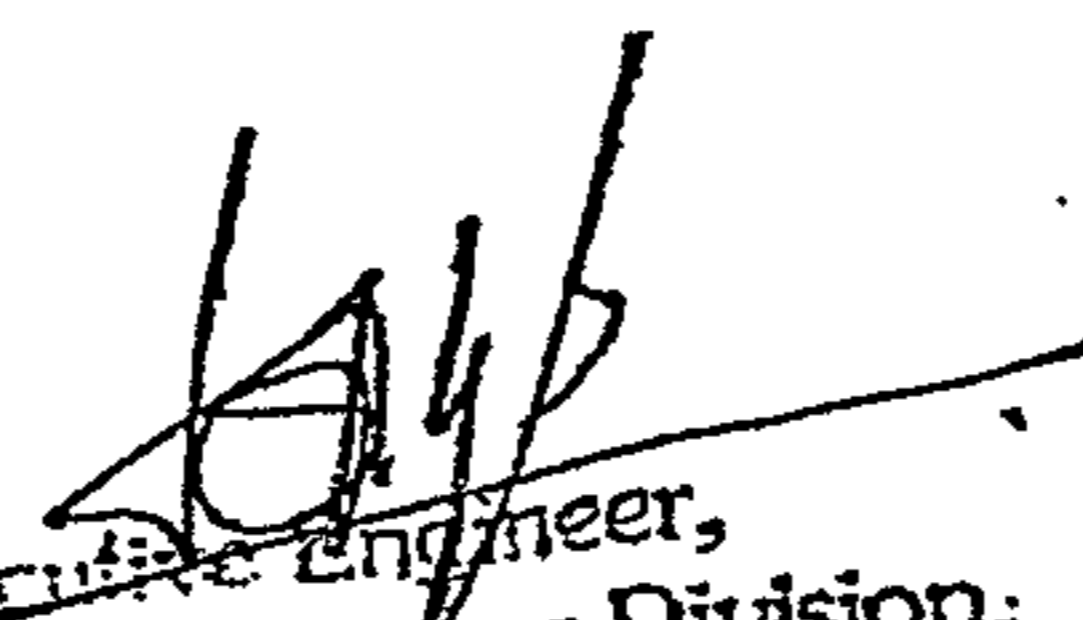
Any person with concerns or complaints about the conduct of a research study can contact the Manager for Ethics Administration, University of Sydney on (612) 9351 4811.



ਹਿੱਸਾ ਲੈਣ ਲਈ ਯੋਗਤਾ ਦੀ ਸੂਚਨਾ
12 ਸਾਲ ਦੀ ਦੰਦਾਂ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਖੋਜ

1. ਇਹ ਵਿੱਦਿਅਕ ਖੋਜ ਕਿਸੇ ਬਾਰੇ ਹੈ?
ਇਹ ਵਿੱਦਿਅਕ ਖੋਜ ਇਸ ਲਈ ਕੀਤੀ ਜਾ ਰਹੀ ਹੈ ਤਾਂ ਜੋ ਦੰਦਾਂ ਨੂੰ ਕੀੜਾ ਨਾ ਲਗਣ ਅਤੇ ਸਿੱਠੀਆਂ ਚੀਜ਼ਾਂ ਦਾ ਇਸਤੇਮਾਲ ਕਿਸ ਤਰ੍ਹਾਂ ਕੀਤਾ ਜਾਵੇ ਇਸ ਬਾਰੇ ਹੈ।
2. ਇਹ ਵਿੱਦਿਅਕ ਖੋਜ ਕੌਣ ਕਰ ਰਿਹਾ ਹੈ ?
ਇਹ ਵਿੱਦਿਅਕ ਖੋਜ ਡਾ. ਅਮਨਦੀਪ ਸਿੰਘ ਕਰ ਰਿਹਾ ਹੈ ਜੋ ਕਿ ਇਕ ਭਾਰਤੀ ਦੰਦਾਂ ਦਾ ਡਾਕਟਰ ਹੈ ਅਤੇ ਸਿਡਨੀ ਆਸਟ੍ਰੇਲਿਆ ਦੀ ਯੂਨੀਵਰਸਿਟੀ ਵਿਚ ਦੰਦਾਂ ਦੀ ਵਿਸ਼ੇਸ਼ ਪੜ੍ਹਾਈ ਕਰ ਰਿਹਾ ਹੈ।
3. ਇਸ ਵਿੱਦਿਅਕ ਖੋਜ ਵਿਖ ਕੀ ਕੀ ਸ਼ਾਮਲ ਹੈ ?
ਇਸ ਵਿੱਦਿਅਕ ਖੋਜ ਵਿਚ ਤੁਹਾਡੇ ਬੱਚਿਆਂ ਦੇ ਖਾਣ ਪੀਣ ਬਾਰੇ ਪੁੱਛਣ ਅਤੇ ਉਨ੍ਹਾਂ ਦੇ ਬੱਚਿਆਂ ਦੇ ਦੰਦਾਂ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਸਵਾਲ ਸ਼ਾਮਲ ਹਨ।
4. ਇਹ ਵਿੱਦਿਅਕ ਖੋਜ ਕਿਨ੍ਹਾਂ ਸਮਾਂ ਲੈਂਦੀ ਹੈ ?
ਇਹ ਵਿੱਦਿਅਕ ਖੋਜ ਪੰਜ ਮਿਨਟ ਤੋ ਘੱਟ ਸਮੇ ਵਿਚ ਕੀਤੀ ਜਾ ਸਕਦੀ ਹੈ।
5. ਕੀ ਮੈਂ ਇਸ ਵਿੱਦਿਅਕ ਖੋਜ ਨੂੰ ਛੱਡ ਸਕਦਾ ਹਾਂ ?
ਹਾਂ, ਤੁਸੀਂ ਇਸ ਵਿੱਦਿਅਕ ਖੋਜ ਨੂੰ ਕਿਸੇ ਵੀ ਸਮੇ ਬਿਨ੍ਹਾਂ ਕਿਸੇ ਜੁਰਮਾਨੇ ਤੇ ਛੱਡ ਸਕਦੇ ਹੋ।
6. ਜੇਕਰ ਮੈਂ ਇਸ ਵਿੱਦਿਅਕ ਖੋਜ ਬਾਰੇ ਕੁਝ ਹੋਰ ਪਤਾ ਕਰਨਾ ਹੋਵੇ ਤਾਂ ਮੈਂ ਕੀ ਕਾਂ ?
ਡਾ. ਅਮਨਦੀਪ ਸਿੰਘ ਨੂੰ ਟੈਲੀਫੋਨ ਨੰਬਰ 98141-29121 ਤੇ ਸੰਪਰਕ ਕਰੋ ਜਾਂ ਉਹਨਾਂ ਨਾਲ ਇਸ ਪਤੇ ਉੱਪਰ ਮਕਾਨ ਨੰਬਰ 235, ਸੈਕਟਰ 7, ਪੰਚਕੂਲਾ, ਹਰਿਆਣਾ ਤੇ ਪੱਤਰ ਵਿਹਾਰ ਕਰ ਸਕਦੇ ਹੋ।

ਜੇਕਰ ਕਿਸੇ ਨੂੰ ਇਸ ਖੋਜ ਬਾਰੇ ਕੋਈ ਸ਼ਿਕਾਇਤ ਹੋਵੇ ਤਾਂ ਉਹ ਮੈਨੇਜਰ ਫਾਰ ਐਥਿਕਸ ਐਂਡ ਮਿਨੀਸਟਰੇਸ਼ਨ, ਯੂਨੀਵਰਸਿਟੀ ਆਫ ਸਿਡਨੀ, ਫੋਨ ਨੰਬਰ (612) 93514811


Executive Engineer,
Pb. W/S. & Sewerage Division,
AMRITSAR.



Dental survey of 12-year-olds

Parent / Guardian Consent Form

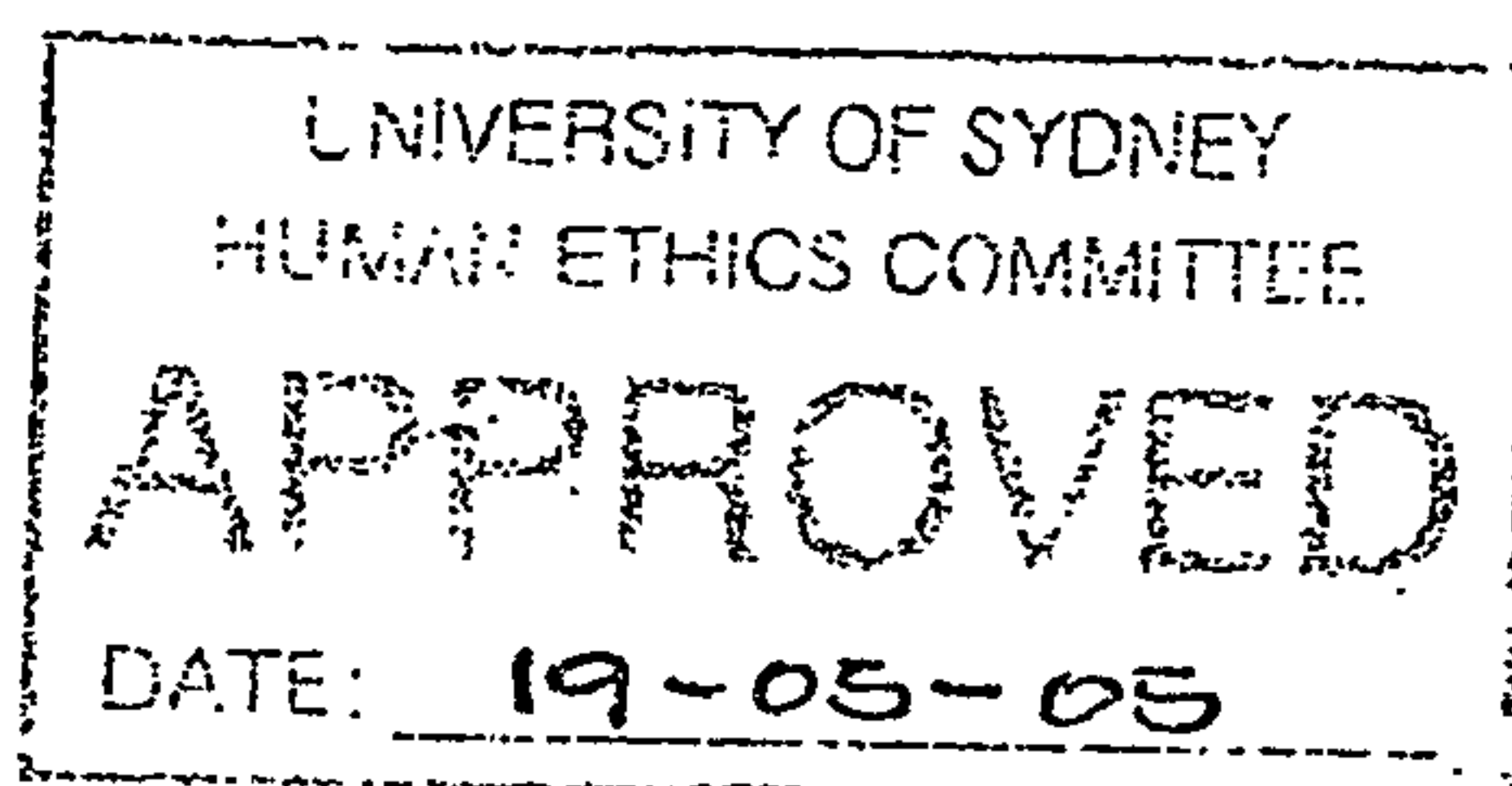
I, permit, who is aged Years, to participate in the Dental Survey of 12-year-olds.

In giving consent I acknowledge that:

1. I have received the Participant Information Statement and that I have read and understood the information given.
2. Dr. Amandeep Singh has given me the opportunity to discuss this information and to ask questions about the project, and they have been answered to my satisfaction.
3. I understand that I can withdraw my child from study at any time without penalty now or in future.
4. I understand that if I have any further questions relating to my child's participation in this survey I may contact Dr. Amandeep Singh who will be happy to answer them.

Signature of parent/ guardian

Date



12 ਸਾਲ ਦੀ ਦੰਦਾਂ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਖੋਜ
ਮਾਂ-ਪਿਓ ਜਾਂ ਆਰਸ਼ਿਤ ਦੀ ਮੰਜੂਰੀ ਦਾ ਫਾਰਮ

ਮੈਂ ਇਹ ਮੰਜੂਰੀ ਦਿੰਦਾ ਹਾਂ ਕਿ 12 ਸਾਲ ਦੀ ਦੰਦਾਂ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈ ਸਕਦਾ ਹਾਂ।

ਮੈਂ ਇਹ ਮੰਜੂਰੀ ਦੇਣ ਲਈ ਇਹ ਹੇਠ ਲਿਖਿਆ ਸ਼ਰਮਤੀ ਪ੍ਰਗਟ ਕਰਦਾ ਹਾਂ:

- 1 ਮੈਂ ਹਿੱਸਾ ਲੈਣ ਲਈ ਯੋਗਤਾ ਦੀ ਸੂਚਨਾ 12 ਸਾਲ ਦੀ ਦੰਦਾਂ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਖੋਜ ਦੀ ਸੂਚਨਾ ਪ੍ਰਾਪਤ ਕਰ ਲਈ ਹੈ। ਇਸ ਨੂੰ ਚੰਗੀ ਤਰ੍ਹਾਂ ਪੜ੍ਹ ਅਤੇ ਸਮਝ ਲਿਆ ਹੈ।
- 2 ਡਾ. ਅਮਨਦੀਪ ਸਿੰਘ ਨੇ ਮੈਨੂੰ ਇਹ ਮੌਕਾ ਦਿੱਤਾ ਹੈ ਕੀ ਮੈਂ ਇਸ ਪ੍ਰੋਜੈਕਟ ਬਾਰੇ ਉਹਨਾਂ ਨਾਲ ਸਲਾਹ ਕਰੇ ਸੱਕਾਂ ਅਤੇ ਉਹਨਾਂ ਨੂੰ ਇਸ ਬਾਰੇ ਸਵਾਲ ਕਰ ਸੱਕਾਂ ਤੇ ਉਹਨਾਂ ਦੇ ਇਹਨਾਂ ਸਵਾਲਾਂ ਦੇ ਜਵਾਬ ਮੇਰੀ ਤੱਥਸ਼ੀ ਯੋਗ ਦੇ ਦਿੱਤੇ ਹਨ।
- 3 ਮੈਂ ਇਹ ਸਮਝ ਲਿਆ ਹੈ ਕਿ ਮੈਂ ਆਪਣੇ ਬੱਚੇ ਨੂੰ ਇਸ ਵਿਦਿਅਕ ਖੋਜ ਤੋਂ ਕਿਸੇ ਵੀ ਸਮੇਂ ਬਗੈਰ ਕਿਸੇ ਜੁਰਮਾਨੇ ਤੋਂ ਛੁਡਵਾ ਸਕਦਾ/ਸਕਦੀ ਹਾਂ।
- 4 ਮੈਂ ਸਮਝ ਲਿਆ ਹੈ ਜੇਕਰ ਮੇਰੇ ਅੰਦਰ ਕੋਈ ਵੀ ਇਸ ਵਿਦਿਅਕ ਖੋਜ ਜਾਂ ਸਰਵੇ ਬਾਰੇ ਸਵਾਲ ਪੈਦਾ ਹੁੰਦਾ ਹੈ ਤਾਂ ਮੈਂ ਡਾ. ਅਮਨਦੀਪ ਸਿੰਘ ਨੂੰ ਸੰਪਰਕ ਕਰ ਸਕਦੀ ਹਾਂ ਜੋ ਕਿ ਇਹਨਾਂ ਸਵਾਲਾਂ ਦੇ ਖੁਸ਼ੀ ਨਾਲ ਸਵਾਗਤ ਕਰਣਗੇ।

ਹਸਤਾਖਰ ਮਾਤਾ ਪਿਤਾ ਅਤੇ ਆਰਸ਼ਿਤ

ਮਿਤੀ

Attested to be true copy of

English version

Dimple
Sub Divisional Engineer,
Pb. W/S. & Sew. S/Divn-8,
Amritsar.

Appendix C.

Clinical Examination Form.

Dental survey of 12-year-olds

Clinical examination form

Name _____ Sex

Duplicate

ID

	17	16	15	14	13	12	11	21	22	23	24	25	26	27
Status			1	1							1	1		
Treatment														
Status			1	1							1	1		
Treatment														
	47	46	45	44	43	42	41	31	32	33	34	35	36	37

STATUS

0 = Sound

1 = Decayed (Decayed = D3)

F = Filled

M = Missing (Missing = missing due to caries)

T = Trauma (Trauma = a broken tooth due to trauma or a filled tooth due to trauma)

8 = Unerupted

TREATMENT

0 = None

F = Filling

X = Extraction

Appendix D.

Questionnaire (English and Punjabi).



Dental survey of 12- year- olds

Questionnaire

- 1. What did you eat or drink before breakfast?
 1) Milk 2) Tea 3) Water 4) none
 5) Other (please specify).....
- 2. How many spoons of sugar did you put in your milk/tea?
 1) 1 2) 2 3) 3 or more 4) 0
- 3. What did you drink for breakfast?
 1) Milk 2) Tea 3) Juice 4) Lassi
 5) Others (please specify)
- 4. How much spoons of sugar you put in your milk/tea?
 1) 1 2) 2 3) 3 or more 4) 0
- 5. What did you eat for breakfast?
 1) Chapatti 2) Bread 3) Nothing 4) Others (please specify)
- 6. If you had curd/lassi did you put sugar in it?
 1) Yes 2) no
- 7. How many spoons of sugar you put?
 1) 0 2) 1 3) 2 4) 3 or more
- 8. What did you have in your Tiffin?
 1) Bread 2) Sweet roti 3) None 4) others (please specify)....
- 9. What did you put on bread?
 1) Jam 2) butter 3) Butter with sugar 4) others (please specify)....
- 10. What did you have for dinner?
 1) Rice 2) Chapatti 3) Bread 4) others (please specify).....

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APPROVED
 DATE: 19-05-05

11. What did you drink for dinner?

- 1) Lassi 2) Water 3) Fizzy drinks 4) Others (please specify).....

12. Do you usually eat anything sweet after dinner?

- 1) Yes 2) no

13. What do you usually have?

- 1) Sweet dish prepared at home 2) Ice cream 3) Plain sugar 4) Gur

14. How often do you have it?

- 1) Everyday 2) Once a week 3) Twice a week 4) Rarely

15. If you have plain sugar/gur how much do you have?

- 1) One teaspoon 2) More than 1 teaspoon
3) One handful 4) More than handful

16. How often do you have fizzy drinks like Pepsi/coke?

- 1) At least once a day 2) Every alternate day
3) At least once a week 4) Once a month

17. Did you also have other sweet drinks during day except sweet lassi or coke?

- 1) Yes 2) No

18. How often do you have it?

- 1) Once a day 2) Every alternate day
3) Once a week 4) Once a month

19. How many sweets do you have in a day?

- 1) 2 2) 4 3) 6 4) 10

20. How often do you have them?

- 1) Once a day 2) Once a week
3) Whenever you feel like 4) Once a month

21. How many sticks of sugarcane do you usually chew?

- 1) 1 2) 2 3) 3 4) 4 or more

22. How many pinglee's do you have from one sugarcane at 1 time?

- 1) 1 2) 2 3) 3 4) Whole sugarcane

23. How many times do you brush your teeth in a day?

- 1) Less than once a day 2) Less than twice a day
3) Less than once a week 4) Less than once a month

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24. What did you put on your toothbrush?

- 1) Colgate 2) Pepsodent 3) Close up 4) Tooth powder
5) Others (please specify).....



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DATE: 19-05-05

12 ਸਾਲ ਦੀ ਦੰਦਾ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਖੋਜ ਪ੍ਰਸ਼ਨਾਵਲੀ

1. ਤੁਸੀਂ ਨਾਸ਼ਤੇ ਤੋਂ ਪਹਿਲਾਂ ਕੁਝ ਖਾਏ ਜਾ ਪੀਏ ਹੋ ?
 1) ਦੁੱਧ 2) ਚਾਹ 3) ਪਾਣੀ 4) ਕੁਝ ਨਹੀਂ
 5) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)
2. ਤੁਸੀਂ ਆਪਣੇ ਦੁੱਧ ਜਾਂ ਚਾਹ ਵਿਚ ਕਿੰਨੇ ਚਮਚੇ ਖੰਡ ਪਾਉਂਦੇ ਹੋ?
 1) 1 2) 2 3) 3 4) 0
3. ਨਾਸ਼ਤੇ ਵਿਚ ਤੁਸੀਂ ਕੀ ਪਾਏ ਹੋ ?
 1) ਦੁੱਧ 2) ਚਾਹ 3) ਜੂਸ 4) ਲੱਸੀ
 5) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)
4. ਤੁਸੀਂ ਆਪਣੇ ਦੁੱਧ ਜਾਂ ਚਾਹ ਵਿਚ ਕਿੰਨੇ ਚਮਚੇ ਖੰਡ ਦੇ ਪਾਉਂਦੇ ਹੋ ?
 1) 1 2) 2 3) 3 4) 0
5. ਨਾਸ਼ਤੇ ਵਿਚ ਤੁਸੀਂ ਕੀ ਖਾਏ ਹੋ ?
 1) ਚਪਾਤੀ 2) ਖੰਡ 3) ਕੁਝ ਨਹੀਂ 4) ਕੁੱਝ ਹੋਰ
 5) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)
6. ਜੇਕਰ ਤੁਸੀਂ ਦੁੱਧ ਜਾਂ ਲੱਸੀ ਲੈਣੀ ਹੈ ਤਾਂ ਉਹ ਵਿਚ ਖੰਡ ਪਾਉਂਦੇ ਹੋ ?
 1) ਹਾਂ 2) ਨਹੀਂ
7. ਤੁਸੀਂ ਕਿੰਨੇ ਚਮਚ ਖੰਡ ਦੇ ਪਾਉਂਦੇ ਹੋ ?
 1) 0 2) 1 3) 2 4) 3 ਜਾਂ ਵੱਧ
8. ਤੁਹਾਡੇ ਟਿਫਨ ਦੇ ਵਿਚ ਕੀ ਹੁੰਦਾ ਹੈ ?
 1) ਜੈਮ 2) ਮਿੱਠੀ ਰੋਟਲ 3) ਕੁੱਝ ਵੀ ਨਹੀਂ
 4) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)
9. ਤੁਸੀਂ ਆਪਣੇ ਖੰਡ ਉਪਰ ਕੀ ਲਗਾਉਂਦੇ ਹੋ ?
 1) ਜੈਮ 2) ਮੱਖਣ 3) ਮੱਖਣ ਅਤੇ ਖੰਡ
 4) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)
10. ਤੁਹਾਡੇ ਰਾਤ ਦੇ ਖਾਣੇ ਵਿਚ ਕੀ ਹੁੰਦਾ ਹੈ ?
 1) ਚਾਵਲ 2) ਚਪਾਤੀ 3) ਖੰਡ
 4) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)
11. ਤੁਸੀਂ ਰਾਤ ਦੇ ਖਾਣੇ ਵਿਚ ਕੀ ਪੀਏ ਹੋ ?
 1) ਲੱਸੀ 2) ਪਾਣੀ 3) ਫਿਜ਼ੀ ਡਰਿੰਕ
 4) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)
12. ਕੀ ਤੁਸੀਂ ਰਾਤ ਦੇ ਖਾਣੇ ਤੋਂ ਬਾਅਦ ਆਮ ਤੌਰ ਤੇ ਮਿੱਠੀ ਚੀਜ਼ ਖਾਂਦੇ ਹੋ ?
 1) ਹਾਂ 2) ਨਹੀਂ
13. ਤੁਸੀਂ ਆਮ ਤੌਰ ਤੇ ਕੀ ਖਾਏ ਹੋ ?
 1) ਘਰ ਵਿਚ ਬਣੀ ਮਿੱਠੀ ਚੀਜ਼ 2) ਆਈਸਕਰੀਮ
 3) ਖੰਡ 4) ਗੁੜ

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12 ਸਾਲ ਦੀ ਦੰਦਾਂ ਦੀ ਬਿਮਾਰੀਆਂ ਬਾਰੇ ਖੋਜ ਪ੍ਰਸ਼ਨਾਵਲੀ

- 14 ਕੀ ਤੁਸੀਂ ਅਕਸਰ ਮਿੱਠਾ ਖਾਦੇ ਹੋ ?
- 1) ਹਰ ਰੋਜ਼ 2) ਹਫਤੇ ਚ ਇਕ ਵਾਰ
3) ਇਕ ਮੁੱਠੀ 4) ਬਹੁਤ ਘੱਟ ਕਦੀ ਕਦੀ
- 15 ਜੇਕਰ ਤੁਸੀਂ ਖੰਡ ਜਾਂ ਗੁੜ੍ਹ ਖਾਦੇ ਹੋ ਤਾਂ ਕਿਨ੍ਹਾ ਖਾਦੇ ਹੋ ?
- 1) ਇਕ ਟੀ ਸਪੂਨ 2) ਇਕ ਤੋਂ ਜਿਆਦਾ ਟੀ ਸਪੂਨ
3) ਇਕ ਮੁੱਠੀ 4) ਇਕ ਤੋਂ ਜਿਆਦਾ ਮੁੱਠੀਆਂ
- 16 ਕੀ ਤੁਸੀਂ ਅਕਸਰ ਫਿਜ਼ੋ ਕ੍ਰਿਕ ਜਿਸ ਤਰ੍ਹਾਂ ਕੀ ਪੇਪਸੀ ਜਾਂ ਕੋਕ ਪੀਂਦੇ ਹੋ ?
- 1) ਦਿਨ ਚ ਇਕ 2) ਇਕ ਦਿਨ ਬਾਦ
3) ਹਫਤੇ ਚ ਇਕ 4) ਮਹੀਨੇ ਚ ਇਕ
- 17 ਕੀ ਤੁਸੀਂ ਲੌਸੀ ਜਾਂ ਕੋਕ ਤੋਂ ਇਲਾਵਾ ਹੋਰ ਵੀ ਮਿੱਠੀਆਂ ਚੀਜ਼ਾਂ ਪੀਂਦੇ ਹੋ ?
- 1) ਹਾਂ 2) ਨਹੀਂ
- 18 ਕੀ ਤੁਸੀਂ ਅਕਸਰ ਪੀਂਦੇ ਹੋ ?
- 1) ਦਿਨ ਚ ਇਕ 2) ਇਕ ਦਿਨ ਬਾਦ
3) ਹਫਤੇ ਚ ਇਕ 4) ਮਹੀਨੇ ਚ ਇਕ
- 19 ਤੁਹਾਡੇ ਇਕ ਦਿਨ ਵਿਚ ਖਾਣ ਪੀਣ ਦੀਆਂ ਮਿੱਠੀਆਂ ਚੀਜ਼ਾਂ ਕਿੰਨੀਆਂ ਹੁੰਦੀਆਂ ਹਨ ?
- 1) 2 2) 4
3) 6 4) 10
- 20 ਕੀ ਤੁਸੀਂ ਅਕਸਰ ਇਹਨਾਂ ਚੀਜ਼ਾਂ ਨੂੰ ਖਾਦੇ ਹੋ ?
- 1) ਹਫਤੇ ਚ ਇਕ ਵਾਰ 2) ਹਫਤੇ ਚ ਇਕ ਵਾਰ
3) ਜਦੋਂ ਤੁਹਾਨੂੰ ਪਸੰਦ ਹੋਵੇ 4) ਮਹੀਨੇ ਚ ਇਕ ਵਾਰ
- 21 ਤੁਸੀਂ ਕਿੰਨੇ ਗੰਨੇ ਅਕਸਰ ਚੱਬਾ ਲੈਂਦੇ ਹੋ ?
- 1) 1 2) 2
3) 3 4) 4 ਜਾਂ ਵੱਧ
- 22 ਇਕ ਸਮੇਂ ਵਿਚ ਇਕ ਗੰਨੇ ਵਿਚੋਂ ਤੁਸੀਂ ਕਿੰਨੀਆਂ ਪਿੰਗਲੀਆਂ ਚਬਾ ਲੈਂਦੇ ਹੋ ?
- 1) 1 2) 2
3) 3 4) ਸਾਰਾ ਗੰਨਾ
- 23 ਤੁਸੀਂ ਇਕ ਦਿਨ ਵਿਚ ਕਿੰਨੀ ਵਾਰ ਦੰਦ ਸਾਫ ਕਰਦੇ ਹੋ ?
- 1) ਦਿਨ ਚ ਘੱਟੋ ਘੱਟ ਇਕ ਵਾਰ 2) ਦਿਨ ਚ ਘੱਟੋ ਘੱਟ ਦੋ ਵਾਰ
3) ਹਫਤੇ ਚ ਘੱਟੋ ਘੱਟ ਇਕ ਵਾਰ 4) ਮਹੀਨੇ ਚ ਘੱਟੋ ਘੱਟ ਇਕ ਵਾਰ
- 24 ਤੁਸੀਂ ਆਪਣੇ ਟੁੱਥ ਬ੍ਰਸ਼ ਉਪਰ ਕੀ ਲਗਾਉਂਦੇ ਹੋ ?
- 1) ਕੋਲਗੇਟ 2) ਪੋਪਸੋਡੈਂਟ 3) ਕਲੋ-ਅਪ 4) ਟੁੱਥ ਪਾਉਡਰ
5) ਕੁੱਝ ਹੋਰ (ਦੱਸਿਆ ਜਾਵੇ)

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Pb. W/S & Sew. S/Divn-8.

Appendix E.

Details of the multiple variable logistic regression analysis.

Details of the multiple variable logistic regression analysis.

At step 1, in the backward stepwise selection model, all potential confounders are entered into the regression at once. The analysis examines each confounder in turn, adjusting for the effects of the others. The p value of 0.956 indicates that sugar consumption at breakfast was a non significant predictor of DMFT and also the least significant variable in the model, and was hence dropped from the model at step 1.

The remaining confounders were assessed at step 2 where the p value of 0.848 indicated that the contribution of Tiffin was also a non significant, and the least significant predictor at this step, and hence dropped from the model.

At steps 3 and 4, lollies and sugar consumption at dinner were eliminated, leaving sugarcane group as the only significant predictor of experiencing one or more DMFT. The odds ratio of 0.507 indicates that compared with non-cane group, the children in the sugarcane group were only 51 percent as likely to have one or more DMFT. The confidence limits of this estimate are 0.327 and 0.784.

Table E. Odds ratios from best fitting multiple variable logistic regression model (using the backward stepwise selection method) for dental caries experience. Respective reference categories were: water; and non-sugarcane area. Caries experience was dichotomised as DMFT = 0 or 1+.

	Explanatory variable	Variable category	Odds ratio	95% CI	p value
Step 1	Breakfast*	Milk	0.905	0.331, 2.473	0.845
		Tea	1.098	0.684, 1.763	0.698
		Yoghurt	1.171	0.511, 2.682	0.710
	Tiffin	Milk	0.819	0.424, 1.583	0.553
		Tea	0.814	0.439, 1.510	0.514
		Yoghurt	1.173	0.339, 4.053	0.801
	Dinner	Milk	0.507	0.236, 1.089	0.082
		Tea	0.721	0.402, 1.292	0.271
		Yoghurt	0.555	0.274, 1.124	0.102
	Lollies	Frequency	1.156	0.730, 1.833	0.536
	Residence	Sugarcane area	0.502	0.304, 0.829	0.007
	Constant		0.698		0.541
	Step 2	Tiffin	Milk	0.827	0.428, 1.595
Tea			0.817	0.441, 1.513	0.520
Yoghurt			1.203	0.350, 4.139	0.770
Dinner		Milk	0.512	0.238, 1.099	0.086
		Tea	0.712	0.399, 1.270	0.250
		Yoghurt	0.554	0.275, 1.117	0.099
Lollies		Frequency	1.153	0.729, 1.826	0.543
Residence		Sugarcane area	0.493	0.302, 0.805	0.005
Constant			0.742		0.604
Step 3	Dinner	Milk	0.506	0.236, 1.086	0.081
		Tea	0.698	0.394, 1.236	0.217
		Yoghurt	0.545	0.279, 1.065	0.076
	Lollies	Frequency	1.155	0.732, 1.824	0.536
	Residence	Sugarcane area	0.509	0.318, 0.815	0.005
	Constant		0.639		0.375
Step 4	Dinner	Milk	0.514	0.240, 1.101	0.087
		Tea	0.702	0.397, 1.243	0.225
		Yoghurt	0.549	0.281, 1.073	0.079
	Residence	Sugarcane area	0.5	0.313, 0.797	0.004
	Constant		0.833		0.493
Step 5	Residence	Sugarcane area	0.507	0.327, 0.784	0.002
	Constant		0.575		0.000

* Indicates sugar-containing beverages as consumed at breakfast. Similarly for tiffin and dinner.

Appendix F.

List of schools surveyed in both the sugarcane and the non-sugarcane growing areas.

Government elementary schools in the sugarcane belt:

Chhiden

Bhangarpur

Mehta (Boys)

Mehta (Girls)

Saiduke

Chung

Chowk Mehta

Government elementary schools in the non-sugarcane growing area:

Gurinda

Gagarbhana

Phalurimanj

Gausabad

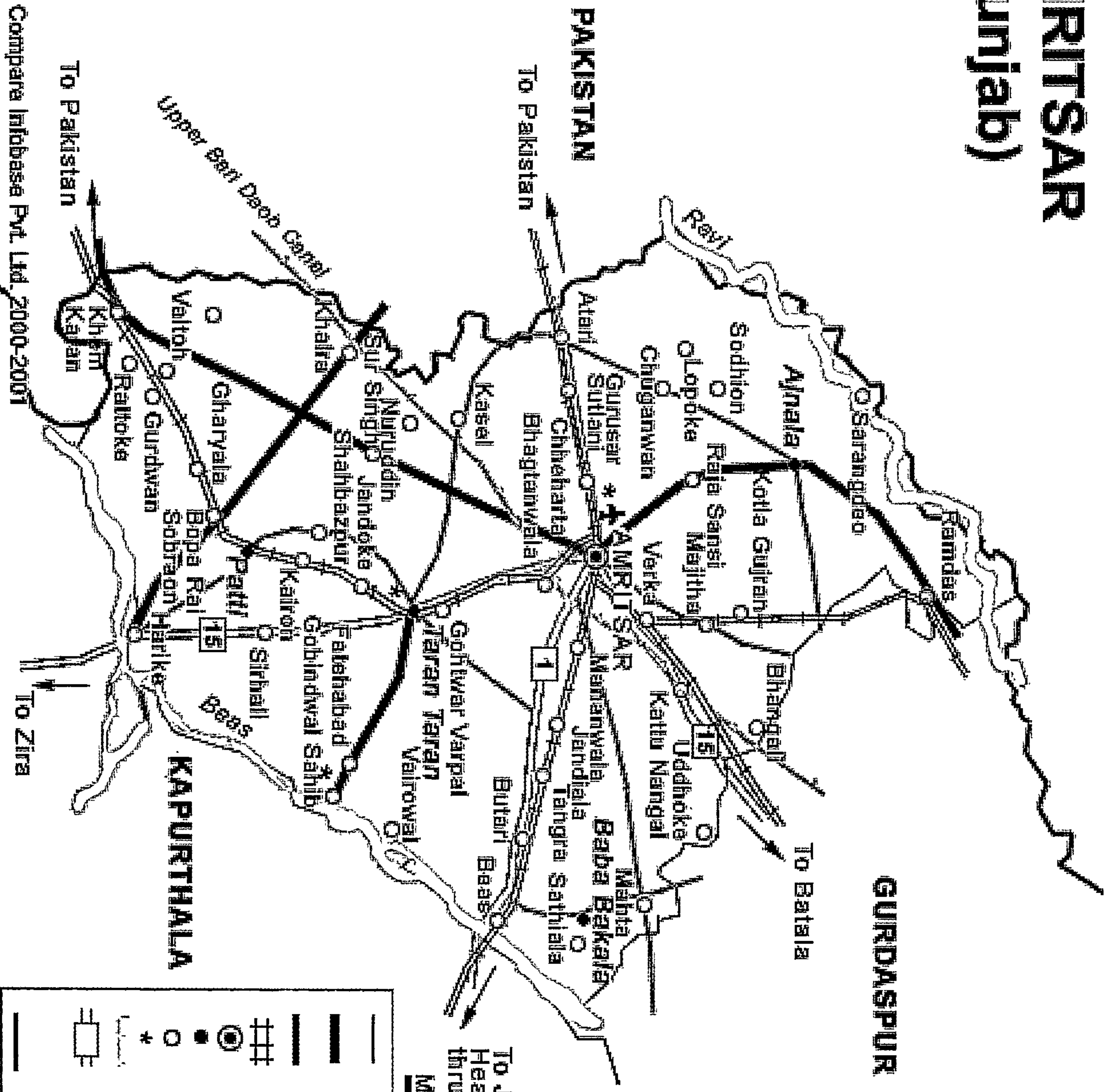
Bhutar Kalan

Bhankarpur

Appendix G.

Map of Amritsar (Punjab).

AMRITSAR (Punjab)



To Jalandhar-District
Headquarter
thru Kapurthala
Map not to Scale

	District Boundary
	Major Road
	Road
	Railway Track
	District Headquarter
	Taluk Headquarter
	Town
	Tourist Place
	National Highway
	River
	International Boundary