ORAL HEALTH STATUS ASSOCIATED WITH SOCIODEMOGRAPHIC FACTORS OF NEPALESE SCHOOLCHILDREN: A POPULATION-BASED STUDY

Karki Saujanya[1,2], Laitala Marja-Liisa[1], Humagain Manoj[2], Seppänen Marjo [3], Päkkilä Jari[4] and Anttonen Vuokko[1,5]
[1]Research Unit of Oral Health Sciences, University of Oulu, Finland, [2]School of Medical Sciences, Kathmandu University, Nepal, [3] Department of Geography, University of Oulu, Finland, [4]Department of Mathematical Sciences, University of Oulu, Finland, [5]Medical Research Center, University of Oulu and Oulu University Hospital, Finland

Running Title

Oral Health of Nepalese Children

Keywords
Dental caries, geo-maps, gingival bleeding, oral health, Nepal

Corresponding Author

Saujanya Karki
Doctoral Student
Research Unit of Oral Health Sciences
University of Oulu
POB 5281, Aapistie 3, FI- 90220, Oulu, Finland
Phone: +385 469497281
saujanya.karki@oulu.fi

Introduction

The global burden of oral diseases has increased over past decades, with dental caries being the most prevalent[1]. Dental caries and periodontal diseases affect majority of children globally[2]. Oral diseases, mainly caries and periodontitis, account for approximately 15 million years of life lost annually[1]. The impact of periodontal diseases on general health is well established[3]. On the other hand, untreated caries may also cause pain, discomfort and even severe general infections[4]. Despite being preventable and treatable, these diseases often remain untreated, particularly in developing countries[5]. There is lack of knowledge on aetiology of the diseases. Poor access to oral health care, especially in remote areas of developing countries, may cause this, while in developed countries, oral health care is mostly included in primary health care (PHC)[6].

Nepal is a land-locked, multi-ethnic country and is divided into three ecological and five administrative developmental regions and 75 districts. The first National Oral Health Pathfinder Survey conducted in Nepal in 2004 among WHO age groups revealed that the prevalence of dental caries is low, except among 5-6-year-olds, but the prevalence of gingivitis is high among all children[7]. According to the WHO recommendation, clinical oral health surveys should be conducted in every 5-6 years to gather information on the oral health situation and services needed[8]. Consequently, a national oral health survey considering all these aspects was considered necessary due to recent changes in the Nepalese society[9].

The aim of this study was to investigate oral health of Nepalese schoolchildren relative to their socio-demography. The hypothesis was that there is residence-related variation in the prevalence of dental caries, but not in the prevalence of gingivitis.

Methods

The present study was a school-based, cross-sectional clinical study conducted among schoolchildren representing WHO index age groups (5-6-, 12- and 15-year-olds) in 27 schools of 18 out of 75 districts of Nepal (Fig. 1).

Sample sites

Stratified random sampling was used considering the ecological regions (Tarai in the south, Mountain in the north and Hill in between) and the administrative developmental regions (Eastern, Central, Western, Mid-Western and Far-Western). Three districts from each five developmental regions were selected to represent simultaneously also each ecological region. In the Kathmandu Valley, the most

densely populated urban area in Nepal, all the three districts were included (Fig. 1). The sample sites were considered as Location with access to oral health care *(or urban*)/Location with no access to oral health care *(or rural)* based on access to a health care clinic (government-operated or private) with a dental office and staff facilities within 10 km from the sample site. The decision was made after consulting a district health officer or primary health centre. Ethnicity among the study population was classified into seven groups as suggested by the Nepal Demography and Health Survey (2006)[10]. After obtaining the list of schools from the Ministry of Education, the sample sites were selected conveniently (one to two schools per district).

Study population

To estimate the sample size, a power calculation was carried out by using the G*power software (GPOWER version 3.1, Samsovej 21, 8382 Hinnerup, Denmark) with 95% power and using the Mann-Whitney U test between means (difference in the number of decayed primary and permanent teeth, d/D = 0.3) with alpha-type error at 0.05. The sample size of n=340 in each age group was considered sufficient.

Lists of students in all age groups were requested from the participant schools prior to the study. All 5-6-year-olds, accompanied by their parents as requested, were included without randomising. A maximum of 60 children in the two oldest age groups could be examined per day, and randomisation had to be carried out as follows: The children were asked to form two lines (according to their age) in the school assembly ground. If for instance 120 children were present, every second child was selected to participate (sample fraction). One school refused to participate and 1137 out of 1151 schoolchildren gave their permission and participated both the survey and clinical examination. The participation rates in each developmental region were Eastern (96.68%), Central (99.64%), Western (97.80%), Mid-Western (100%), and Far-Western (100%).

The age (birth year) and date of birth of each child were obtained from the school authorities and recorded in the individual data collecting sheet prior to the study.

Clinical examination

The clinical examination was conducted according to the WHO guidelines and criteria[8]. The protocol was confirmed during the training sessions. Clinical examinations were performed in the school premises using external (LED) headlights, intra-oral mirrors, and the WHO Community Periodontal

probes. The examiners wore a uniform, a disposable mask, and gloves. The participant lay down on a bench and the examiner was seated behind them.

Cariological status

The cariological status was evaluated at tooth level by visual-tactile examination investigating the depth and estimating activity, as well as the texture of tooth surfaces by using the WHO probe. Teeth were not cleaned professionally or air-dried prior to the examination. Each tooth was scored as *sound, decayed, filled with or without caries, missing due to caries, fissure sealed.* Teeth with even one surface affected were considered carious or filled. Missing due to caries was confirmed by asking the cause from the participant/parent.

pufa/PUFA

The recently developed pufa/PUFA index measures the consequences of untreated dental caries[11]. The index measures the following: *visible pulp or pulp involvement (p/P), ulceration of the oral mucosa due to root fragments (u/U), a fistula (f/F) or an abscess (a/A).* The pufa/PUFA index was assessed as advised originally[11] and the lowercase letters were used for primary dentition and uppercase letters for permanent dentition. Only one score was assigned per tooth. In addition to mean pufa/PUFA scores (SD), pufa/PUFA sum scores were calculated as the total number of teeth with any pufa/PUFA criterion.

Gingival status

Gingiva of all teeth present was examined at six sites *(distobuccal, midbuccal, mesiobuccal, distolingual, midlingual, mesiolingual).* The tip of the probe was gently inserted between the gingiva and the tooth following the anatomical configuration. A per-tooth score was registered based on *absence or presence of bleeding* at any of the sites.

Dental trauma

If any signs of treated/untreated trauma were present, the tooth was recorded as traumatised as follows: *enamel fractured only, enamel and dentine fracture, pulp involvement, missing tooth due to trauma, treated trauma*.

Fluorosis

The modified Dean's fluorosis index was used to record enamel fluorosis[12]. The index categorises fluorosis as follows: *normal, questionable, very mild, mild, moderate* or *severe*.

Treatment urgency

According to clinical findings, individuals were provided with one of the following scores: *no oral treatment need, preventive treatment needed (no caries, mild gingivitis), prompt treatment needed (caries, gingivitis)* or *immediate treatment needed.*

Quality control and quality assurance

Three registered Nepali dentists were trained and calibrated to conduct the clinical examinations. All findings were recorded manually on data collection sheets based on the WHO model[8] by two trained enumerators. Two senior researchers with experience of similar oral health surveys and validation processes conducted the training and calibration sessions.

Training provided in April 2016 covered both theoretical and practical lessons. All the trainees were provided with the WHO manual[8]. The lecture provided detailed information with illustrations on the clinical parameters to be investigated. During the calibration, 20 extracted teeth with a variety of carious lesions were examined. A consensus was reached by the examiners and trainees about the score. The examiners were trained to use 20 g gingival probing force with the help of a letter scale (Electronic Letter Scale, Art. no 34-9710, China).

After the theory session, the trainees, under the supervision of the trainers, recorded clinical findings of five children from each age group and the enumerators practised recording the findings. To ensure a high quality of the clinical examination, the training session was repeated briefly before the field stage and again one week later. Because the field stage lasted only two and half months, further training or calibration was not considered necessary. The intra-examiner agreement was calculated by using extracted teeth and it ranged from 0.84 to 0.97. A total of five children were examined by the three examiners, while the trainers acted as the golden standard. The inter-examiner kappa value for d/D was 0.87, pufa/PUFA was 0.63, dental traumas were 1.00, and fluorosis was 0.53.

Fluoride in drinking water

To assess the concentration of fluoride in school drinking water, water samples (500 ml) were collected in commercially available clean and dry bottles. The fluoride concentration (ppm) was assessed by using the SPANDS fluoride reagent solution (Hach Company, Colorado, United States).

Ethical clearance

The study protocol and material were approved by the Ethical Committee, School of Medical Sciences, Kathmandu University (IRC No. 60/15, KUSMS) and a permission for the study was also obtained from the Northern Ostrobothnia Hospital District (18/2016). The ethical committee also approved the consent procedure. The entire study was conducted in full accordance with the World Medical Association Declaration of Helsinki. The Ministry of Health and the Ministry of Education, Government of Nepal, gave their written permission for the study, and the district health and education authorities also gave their permission. The schools were contacted via an informative letter describing the study. A written consent was required from the school headmaster before starting the field phase. A letter was also sent requesting participation of the older children and parents of the youngest ones. Parents of the youngest children gave a written consent while a verbal consent was obtained and recorded from the older ones. Participation was voluntary and the clinical examination caused no physical harm or pain to the participants.

Statistical analysis

The data recorded manually on data sheets were transferred to the SPSS software (IBM SPSS Statistics for Windows, version 24.0. Armonk, NY: IBM Corp.) for analyses.

Demographic information about the study population was presented for age group, gender (m/f), location with access to oral health care (*urban/rural*), ecological region, developmental region, ethnicity, and district. The mean values (SD) of d/D, dmf/DMF (d/D>0 indicating a present caries treatment need and dmf/DMF>0 a present caries treatment need and past caries experience), pufa/PUFA (p/P pulp involvement, u/U ulceration due to root fragments, f/F fistula, and a/A abscess), BOP (number of teeth with gingival bleeding) were calculated. Proportions of children with d/D/dmf/DMF>0, pufa/PUFA>0, dental traumas>0, fluorosis >0, and BOP *>15%* and with different treatment needs were calculated.

The t-test and one-way ANOVA were used to compare the means between the groups. To compare the proportions between groups, the chi-square test was performed. To assess the effect of geographical variation on dental caries prevalence, a binary logistic regression model was carried out (odds ratios OR and 95% CI), having untreated carious lesions (d/D) as the dependent variable and gender and place of residence as the independent variables - the Kathmandu Valley was used as the

reference and the OR estimates were illustrated by using geo-mapping. The statistical significance level was set at p-value *<0.05*.

Geographic Information System (GIS)

To visualise the results in the present study, the examination sites were geo-referenced and imported to ArcGIS, version 10.5 (Environmental Systems Research Institute, Inc., Redlands, CA, USA), to create geo-maps.

Results

Altogether 1,137 children were examined clinically. Among the study group, the proportion of the children was quite evenly distributed by age and gender. (Table 1). The proportion of those requiring restorative treatment (d/D>0) was 78.8% among the 5-6-year-olds, 53.4% among the 12-year-olds, and 60.8% among the 15-year-olds. Proportions of those with d/D>0 and dmf/DMF>0 were almost identical. (Table 2).

Among the 5-6-year-olds, the prevalence of dental caries was significantly higher among participants from the Western region compared to the other ones (Table 2). Among them, a higher risk for restorative treatment need (d) *per se* was discovered in remote districts (Banke, Mugu, Mustang, Okhaldhunga, Palpa and Surkhet) compared to the Kathmandu Valley (Figure 1). On the other hand, living outside the Kathmandu Valley was a protective factor among the 12- and 15-year-olds. As for the ecological regions, among all age groups, the restorative treatment need was the lowest in Tarai and the highest in the Mountain region (Table 2, Figure 1).

Among the youngest children, the prevalence of those with pufa/PUFA>0 was the highest (87.1%), while the respective figures were 8.5% for the 12-year-olds and 15.9% for the 15-year-olds. The most common sequel of untreated dental caries was pulpitis followed by abscesses and fistulae; the difference between the prevalence of the components was statistically significant (p<0.001) between the 5-6-year-olds and the 15-year-olds (Table 3).

From the youngest to the oldest age group, the mean number of teeth with BOP was 13.1 (SD 4.87), 14.8 (SD 6.52), and 19.0 (SD 6.58). The proportion of those with BOP>15% was more than 90% in all age groups. Additionally, children location with no access to oral health care (rural) had significantly higher BOP than the rest (Table 4). The prevalence of dental traumas was 1.8% for the

5-6-year-olds, while the respective figures for the 12- and 15-year-olds were 5.1% and 6.3%. The prevalence was similar throughout the country (Table 4).

In most districts, the fluoride level was low, exceeding 0.8 ppm only in one district (Parsa) and only 4% of the study population was exposed to optimal level of fluoride in drinking water (Table 5). A high fluoride concentration was associated with reduced caries experience while no significant effect of optimal fluoride level was found for permanent dentition (Table 5). Fluorosis was seen in 4.1% of the 5-6-year olds, in 11.8% of the 12-year-olds and in 12.8% of the 15-year-olds. In all three age groups, those living in the Eastern and Tarai regions and in urban locations had significantly more frequently fluorosis than the rest (Table 4).

Majority of the children (73.6%) needed prompt treatment, while only 0.8% needed preventive treatment. About a fourth (25.6%) needed treatment urgently. The proportion of those needing treatment urgently was significantly higher (46.2%) among the 5-6-year-olds compared to the 12-year-olds (14.5%) and the 15-year-olds (15.1%) ($p<0.001$). Children from the Mountain region ($p=0.051$) and the Central developmental region ($p<0.001$) or belonging to the Brahaman/Chhetri ethnic group ($p=0.317$) needed treatment more urgently than the rest.

Discussion

Epidemiological studies on oral health must be routinely conducted to monitor the trends and risks of oral diseases. The present cross-sectional study provides information about the current oral health situation among schoolchildren in Nepal, a developing country. An increasing trend in the prevalence of oral diseases among Nepalese children was found when the results were compared to the previous National Oral Health Pathfinder Survey[7] conducted in Nepal. Particularly, the caries and gingival status of 5-6-year-olds are alarming. The number of subjects (in each age group) and the number of sample sites in the present study is harmonious with the WHO recommendation on pathfinder survey[8]. Furthermore, the 18 out of 75 districts also include one metropolitan city (Kathmandu), four sub-metropolitans (Bhaktapur, Birgunj, Butwal, Lalitpur), two major cities (Mahendranagar, Nepalgunj), and eleven villages (Fig 1).

Geographic variation in oral diseases here supports earlier findings concerning the link between diseases, access to health services and socio-demographic background[13, 14], indeed, including the place of residence in analyses enhances the value of a cross-sectional study such as this one[15]. In Nepal, majority of children reported high consumption of sugar-containing foods[16, 17]. Moreover,

industrial foods enriched with fermentable carbohydrates are nowadays easily available in all parts of Nepal[17]. Lack of knowledge of the impacts of such harmful diet may, indeed, be one reason for poor oral health. The importance of oral health habits (mainly dietary sugar, and tooth brushing) in dental caries prevalence was recently reported in a 6 year follow-up study conducted in the North-Korea[18].

In addition to behavioural factors, the high prevalence of untreated dental caries and gingival bleeding in the Mountain and Western regions region may be due to limited oral health promotion, lack of preventive measures and access to oral health services. A recent study on dentist-population ratio in Nepal support our findings[19]. The dentist density and distance related oral health services have been found to influence oral health service use and oral health behaviours also elsewhere[20]. The association between ethnicity and caries experience was evident here mainly in indigenous (Newari and Janajati) children, and caries experience was even higher than previously reported concerning the Chepang children[21]. The possible explanation for this might be the low socio-economic status and low literacy rate among Dalits and Janajati, but not among the Newaris[22]. The cause of high caries level among Newari children can only be speculated, maybe dietary factors and oral hygiene habits, but this need further investigations. These findings should be borne in mind while making health promotion policies and planning and targeting resources.

Caries with harmful consequences was most prevalent in primary dentition. This suggests that environmental, socio-demographic and behavioural factors pose a real risk to Early Childhood Caries (ECC) in today's Nepal[23]. In all age groups, hardly any of the lesions had been restored, which was the reason for identical figures on mean dt/DT and dmft/DMFT values. As for caries status, epidemiological studies conducted in Sudan[24], Bhutan[25], and Albania[26] were in concordance with the present study whereas the caries prevalence among Afghani[27], and Lao[15] children is higher. This mean caries experience clearly reflects the increasing trend in tooth decay in low- and middle-income countries, emphasis should be put on prevention, because disparities exist.

BOP was considered to indicate gingivitis[28], because it has previously been reported to have a good correlation with the Gingival Index scores two and three[29]. The results can be considered reliable when trained and calibrated examinations are carried out by probing and using standard force[30]. The prevalence of BOP was in general high, and significantly higher in rural than in urban communities, which is in concordance with results reported in Laos[15] and Brazil[31] among 12-year-olds. Our results indicate future periodontal disease among the participants if left untreated[32]. Interestingly, gingival

bleeding on probing (BOP) tended to be higher in the older age groups and among girls. This supports the impact of hormonal changes on periodontium during puberty[33].

The prevalence of dental traumas was low compared to previous studies conducted among these age groups[15, 34]. Accidents and sports are known to cause traumas[35], and this should also be investigated in Nepal. Among the 12-year-olds, the prevalence of fluorosis here is identical with findings from Sudan[24].

The sample size was determined at baseline on the basis of power calculations. Despite of the randomization in older age group, a shortcoming of the study is that the schools in each district were conveniently selected which might have led to possibilities of selection bias. Furthermore, not considering the clustered design and data during analysis can be considered as a limitation of our study. The children in the youngest age group accompanied by their parents were included. The decision on the *urban/rural* based on access to oral health care was practical, because of the centralization of the dental care only in the major cities which are all located only in Tarai and in the Kathmandu and Pokhara valleys but not in every district.

The sample represented different ecological, developmental and locations (urban/rural). Both the intra- and the inter-examiner agreement indicate that the outcome is reliable. Inclusion of bitewing radiograph would have been valuable, but in this case it was not possible[36]. However, the protocol included the rarely used pufa/PUFA index, which indicates the severity of caries status. Furthermore, the field-sites, training and the protocol followed the WHO guidelines and standardised validation methods[8], and the agreement within and between the examiners varied from moderate to good for all variables[37]. In addition, multiple variables were included in the protocol, as suggested by WHO[8].

Geographic Information System (GIS) is an innovation of science that provide a complete overview on analysis of geographic variation of the disease. The inclusion of geo-mapping in the present study gave valuable and new information on association between residence and oral health, as done earlier in developed countries[38,39]. Geo-mapping can be used for planning and for reviewing the outcome of health policies[40].

The results from present study support and suggest the need for more effective population-based preventive programmes. Role of fluoride in preventing dental caries is well established. Cost effective methods like water fluoridation and salt fluoridation are beneficial[41]. However, the water fluoridation

is not feasible Nepal as people use multiple sources (more than 40,000) for drinking water[42]. Possibility of salt fluoridation should be investigated, as there is only salt trading company for iodine processing[42]. Brushing with fluoridated toothpaste is most effective and widely used topical fluoride practice, and is becoming common also in Nepal, when at late 90's when fluoridated toothpaste became easily available[43]. Furthermore, the problem on affordability and accessibility of fluoridated toothpaste in Nepal still exists; all pastes are imported from multinational private companies; and prices have remained high for ordinary citizens due to taxes. The measures to reduce the cost of fluoridated tooth paste include reducing taxes and producing tooth paste locally in developing countries as was proposed previously by Goldman et al. (2008)[44]. Tooth brushing should also be improved when majority of Nepalese children report brushing their teeth only once per day[16]. Similarly, annual Silver Diamine Fluoride[45] application could be integrated with on-going Nepal National Vitamin A Program (NVAP), which could decrease the incidence of Early Childhood Caries (ECC). Nevertheless, the cost and time effective programs must be implemented.

The original hypothesis that there is residence-related variation in the prevalence of dental caries was confirmed. Dental caries with serious consequences is common especially among 5-6-year-old Nepalese children and particularly in the Western developmental region. In all age groups, the situation was the best in Tarai, where in 3 out of 7 districts, the fluoride concentration was 0.5 ppm or higher. This should be further investigated. Schoolchildren from the Mountain region and from the Kathmandu Valley have a higher risk for dental caries compared to other children. The cause for this can only be speculated, but it may be due to behavioural issues. Behaviour modifications, such as tooth brushing with fluoridated toothpaste, and limiting the sugar intake as recommended by the WHO guidelines (<10% of total energy) will reduce the risk of dental caries as well as other possible non-communicable diseases[46]. Gingival bleeding, a sign of a risk of periodontal disease in the future, is common throughout the country and in all age groups. Geo-mapping is a valuable tool and should be utilised in the monitoring of oral health and its risk factors in populations. In conclusion, the present study highlights the need for national oral health promotion programmes and the primary health care based dental services in Nepal.

References

1. Marcenes W, Kassebaum NJ, Bernabé E, et al. Global burden of oral conditions in 1990-2010: a systematic analysis. *J Dent Res* 2013 92: 592-597.

2. World Health Organization. *Oral health Fact Sheet*. Geneva: WHO; 2012.

3. Mathews MJ, Mathews EH, Mathews GE. Oral health and coronary heart disease. *BMC Oral Health* 2016 16: 122.

4. Gonçalves L, Lauriti L, Yamamoto MK, Luz JGC. Characteristics and management of patients requiring hospitalization for treatment of odontogenic infections. *J Craniofac Surg* 2013 24: 458.

5. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. *Bull World Health Organ* 2005 83: 661-669.

6. Kandelman D, Arpin S, Baez RJ, Baehni PC, Petersen PE. Oral health care systems in developing and developed countries. *Periodontol 2000* 2012 60: 98-109.

7. Yee R, Mishra P. *Nepal National Oral Health 'Pathfinder' Survey* 2004. Kathmandu: Oral Health Focal Point, Ministry of Health, Nepal 2004.

8. World Health Organization. *Oral Health Surveys: Basic Methods, 5th ed.* Geneva: World Health Organization 2013.

9. Adhikary D. Economic effects of conflict on the Economy in Nepal: before and after 2006. *e-JSBRBJ* 2016 7: 39-53.

10. Lynn B, Dahal DR, Govindasamy P. *Caste, Ethnic and Regional Identity in Nepal: Further Analysis of the 2006 Nepal Demographic and Health Survey.* Calverton, Maryland, USA: Macro International Inc 2008.

11. Monse B, Heinrich-Weltzien R, Benzian H, Holmgren C, van Palenstein Helderman W. PUFA--an index of clinical consequences of untreated dental caries. *Community Dent Oral Epidemiol* 2010 38: 77-82.

12. Rozier RG. Epidemiologic indices for measuring the clinical manifestations of dental fluorosis: overview and critique. *Adv Dent Res* 1994 8: 39-55.
13. Do LG. Distribution of caries in children: variations between and within populations. *J Dent Res* 2012 91: 536-543.
14. Oulis CJ, Tsinidou K, Vadiakas G, Mamai-Homata E, Polychronopoulou A, Athanasouli T. Caries prevalence of 5, 12 and 15-year-old Greek children: a national pathfinder survey. C*ommunity Dent Health* 2012 29: 29-32.
15. Jürgensen N, Petersen PE. Oral health and the impact of socio-behavioural factors in a cross sectional survey of 12-year old school children in Laos. *BMC Oral Health* 2009 9: 29.
16. Karki S, Laitala M, Humagain M, Päkkila J, Anttonen V. Adaptation and Validation of a Nepali Version of the Child-Oral Impacts on Daily Performances Index (Child-OIDP). *Community Dent Health* (accepted for Publication)
17. Tarvonen P-, Suominen AL, Yang GS, Ri YS, Sipilä K. Association between oral health habits and dental caries among children in Pyongyang, Democratic People's Republic of Korea. *Int J Dent Hyg* 2017 15:e142.
18. Subedi YP, Marais D, Newlands D. Where is Nepal in the nutrition transition? *Asia Pac J Clin Nutr* 2017 26:358-367.
19. Shrestha RM, Shrestha SS, Kunwar N. Dentists in Nepal: A Situation Analysis. *J Nepal Health Res Counc* 2017 15:187-192.
20. Emami E, Wootton J, Galarneau C, Bedos C. Oral health and access to dental care: a qualitative exploration in rural Quebec. *Can J Rural Med* 2014 19:63-70.
21. Prasai Dixit L, Shakya A, Shrestha M, Shrestha A. Dental caries prevalence, oral health knowledge and practice among indigenous Chepang school children of Nepal. *BMC Oral Health* 2013 13: 20.
22. Subba C, Pyakuryal B, Shiromani Bastola T, Khajum Subba M, Raut N, Karki B. A study on Socio-Economic Status of Indigenous Peoples in Nepal. 1st ed, pp 27-104. Kathmandu: LAHURNIP, 2014.
23. Davies GN. Early childhood caries--a synopsis. *Community Dent Oral Epidemiol* 1998 26: 106-116.
24. Nurelhuda NM, Trovik TA, Ali RW, Ahmed MF. Oral health status of 12-year-old school children in Khartoum state, the Sudan; a school-based survey. *BMC Oral Health* 2009 9: 15.
25. Ngedup S, Phurpa D. National oral health survey in 6- and 12-year-old Bhutanese school children. *Bhutan Health Journal* 2017 2:11-17.

26. Hysi D, Caglar E, Droboniku E, Toti C, Kuscu OO. Dental caries experience among Albanian pre-school children: a national survey. *Community Dent Health* 2017 34:46-49.
27. Schwendicke F, Doost F, Hopfenmüller W, Meyer-Lueckel H, Paris S. Dental caries, fluorosis, and oral health behavior of children from Herat, Afghanistan. *Community Dentistry and Oral Epidemiology* 2015 43:521-531.
28. Checchi L, Montevecchi M, Checchi V, Zappulla F. The relationship between bleeding on probing and subgingival deposits. An endoscopical evaluation. *Open Dent J* 2009 3: 154-160.
29. Chaves ES, Wood RC, Jones AA, Newbold DA, Manwell MA, Kornman KS. Relationship of "bleeding on probing" and "gingival index bleeding" as clinical parameters of gingival inflammation. *J Clin Periodontol* 1993 20: 139-143.
30. Eaton KA, Rimini FM, Zak E, Brookman DJ, Newman HN. The achievement and maintenance of inter-examiner consistency in the assessment of plaque and gingivitis during a multicentre study based in general dental practices. *J Clin Periodontol* 1997 24: 183-188.
31. Tomazoni F, Vettore MV, Zanatta FB, Tuchtenhagen S, Moreira CHC, Ardenghi TM. The associations of socioeconomic status and social capital with gingival bleeding among schoolchildren. *J Public Health Dent* 2017 77: 21-29.
32. Lang NP, Joss A, Orsanic T, Gusberti FA, Siegrist BE. Bleeding on probing. A predictor for the progression of periodontal disease? *J Clin Periodontol* 1986 13: 590-596.
33. Mombelli A, Gusberti FA, van Oosten MA, Lang NP. Gingival health and gingivitis development during puberty. A 4-year longitudinal study. *J Clin Periodontol* 1989 16: 451-456.
34. Blokland A, Watt RG, Tsakos G, Heilmann A. Traumatic dental injuries and socioeconomic position - findings from the Children's Dental Health Survey 2013. *Community Dent Oral Epidemiol* 2016 44: 586-591.
35. Glendor U. Aetiology and risk factors related to traumatic dental injuries--a review of the literature. *Dent Traumatol* 2009 25: 19-31.
36. Agustsdottir H, Gudmundsdottir H, Eggertsson H, et al. Caries prevalence of permanent teeth: a national survey of children in Iceland using ICDAS. *Community Dent Oral Epidemiol* 2010 38: 299-309.
37. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)* 2012 22: 276-282.
38. Strömberg U, Holmn A, Magnusson K, Twetman S. Geo-mapping of time trends in childhood caries risk--a method for assessment of preventive care. *BMC Oral Health* 2012 12: 9.
39. Kämppi A, Tanner T, Päkkilä J, et al. Geographical distribution of dental caries prevalence and associated factors in young adults in Finland. *Caries Res* 2013 47: 346-354.

40. Dummer TJB. Health geography: supporting public health policy and planning. *CMAJ* 2008 178: 1177-1180.
41. Mullane DM, Baez RJ, Jones S, Lennon MA, Petersen PE, Rugg-Gunn AJ, et al. Fluoride and Oral Health. *Community Dent Health* 2016 33:69-99.
42. Petersen PE, Baez RJ, Lennon MA. Community-oriented administration of fluoride for the prevention of dental caries: a summary of the current situation in Asia. *Adv Dent Res* 2012 24:5-10.
43. Yee R, McDonald N, Walker D. An advocacy project to fluoridate toothpastes in Nepal. *Int Dent J* 2003 53:220-230.
44. Goldman AS, Yee R, Holmgren CJ, Benzian H. Global affordability of fluoride toothpaste. *Globalization and Health* 2008 4:7.
45. Chu CH, Lo ECM, Lin HC. Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries in Chinese pre-school children. *J Dent Res* 2002 81:767-770.
46. Guideline: Sugars intake for adults and children. Geneva: World Health Organization 2015.

Table 1. Demographic information of the study population

Characteristics	Participants (%)			Total % (n)
	5-6-year-olds (n = 340)	12-year-olds (n = 414)	15-year-olds (n = 383)	
Gender				
Boys	51.8	51.4	54.3	52.5 (597)
Girls	48.2	48.6	45.7	47.5 (540)
Developmental Regions				
Eastern	15.9	21.7	23.2	20.5 (233)
Central	23.8	22.2	28.7	24.9 (283)
Western	19.4	20.3	19.1	19.6 (223)
Mid-western	17.4	15.0	9.1	13.7 (156)
Far-western	23.5	20.8	19.8	21.3 (242)
Ecological Region				
Mountain	31.8	32.6	30.5	31.7 (360)
Hill	50.6	47.3	47.3	48.3 (549)
Tarai	17.6	20.0	22.2	20.1 (228)
Location				
With access to oral health care (Urban)	50.9	51.7	57.2	53.3 (606)
With no access to oral health care (Rural)	49.1	48.3	42.8	46.7 (531)
Ethnic Groups				
Brahaman/ Chhetri	51.8	49.0	45.7	48.7 (554)
Tarai Madhesi	3.2	4.3	7.0	4.9 (56)
Dalits	10.3	9.7	7.8	9.2 (105)
Newar	5.0	4.8	9.1	6.3 (72)
Janajati	27.6	29.5	28.7	28.7 (326)
Muslim	2.1	2.7	1.6	2.1 (24)

Table 2. Mean (SD) dental caries experience, untreated dental caries, and pufa/PUFA experience in relation to age group, gender, location, developmental region, ecological region, and ethnicity.

Variables	5-6-year-olds			12-year-olds			15-year-olds		
	dmf[a] Mean (SD)	d[b] Mean (SD)	pufa[c] Mean (SD)	DMF[a] Mean (SD)	D[b] Mean (SD)	PUFA[c] Mean (SD)	DMF[a] Mean (SD)	D[b] Mean (SD)	PUFA[c] Mean (SD)
Gender									*[d]
Boys	5.22 (4.14)	5.16 (4.10)	1.29 (1.74)	1.28 (1.87)	1.24 (1.82)	0.09 (0.32)	1.88 (2.20)	1.77 (2.16)	0.23 (0.68)
Girls	4.71 (4.40)	4.66 (4.35)	1.28 (2.08)	1.47 (1.72)	1.44 (1.70)	0.11 (0.38)	2.11 (2.53)	2.00 (2.41)	0.33 (0.82)
Location									
Urban	5.06 (4.52)	4.98 (4.45)	1.24 (1.98)	1.29 (1.74)	1.26 (1.71)	0.11 (0.35)	1.85 (2.19)	1.74 (2.14)	0.28 (0.78)
Rural	4.88 (4.01)	4.86 (3.98)	1.33 (1.84)	1.45 (1.87)	1.42 (1.82)	0.10 (0.35)	2.18 (2.56)	2.05 (2.45)	0.27 (0.71)
Developmental Region	**[e]	**[e]	*[e]						
Eastern	5.47 (3.81)	5.39 (3.70)	1.48 (2.09)	1.33 (1.76)	1.30 (1.72)	0.11 (0.34)	2.24 (2.97)	2.18 (2.95)	0.34 (0.85)
Central	4.02 (3.95)	3.94 (3.89)	0.78 (1.27)	1.81 (2.02)	1.78 (2.00)	0.12 (0.42)	1.99 (2.08)	1.86 (2.02)	0.14 (0.44)
Western	7.13 (5.00)	7.07 (4.96)	1.92 (2.38)	1.40 (1.96)	1.33 (1.93)	0.15 (0.42)	1.95 (2.14)	1.70 (1.78)	0.28 (0.68)
Mid-western	4.45 (3.84)	4.45 (3.84)	1.07 (1.65)	1.12 (1.51)	1.12 (1.51)	0.05 (0.22)	1.43 (2.16)	1.32 (2.07)	0.40 (1.04)
Far-western	4.20 (3.95)	4.18 (3.90)	1.23 (1.91)	1.10 (1.55)	1.06 (1.49)	0.05 (0.22)	1.98 (2.24)	1.95 (2.24)	0.31 (0.82)
Ecological Region				**[e]	**[e]		*[e]	*[e]	
Mountain	5.60 (4.40)	5.55 (4.38)	1.55 (1.91)	1.78 (2.00)	1.73 (1.95)	0.15 (0.45)	2.48 (2.73)	2.29 (2.59)	0.37 (0.83)
Hill	4.80 (4.13)	4.73 (4.04)	1.13 (1.87)	1.34 (1.75)	1.32 (1.73)	0.08 (0.29)	1.94 (2.18)	1.83 (2.14)	0.21 (0.65)
Tarai	4.34 (4.37)	4.34 (4.37)	1.27 (1.99)	0.76 (1.34)	0.75 (1.34)	0.08 (0.27)	1.39 (2.04)	1.38 (2.00)	0.25 (0.77)
Ethnic Group				*[e]	*[e]	*[e]			
Brahaman/ Chhetri	4.98 (4.06)	4.92 (3.98)	1.28 (1.90)	1.22 (1.60)	1.21 (1.59)	0.06 (0.26)	1.94 (2.26)	1.86 (2.23)	0.29 (0.72)
Tarai Madhesi	3.28 (2.97)	3.28 (2.97)	0.82 (1.48)	0.67 (1.24)	0.56 (0.99)	0.06 (0.24)	1.71 (2.19)	1.63 (2.08)	0.08 (0.27)
Dalits	4.75 (4.39)	4.72 (4.35)	1.28 (2.01)	1.00 (1.64)	0.93 (1.48)	0.10 (0.45)	1.74 (2.07)	1.74 (2.07)	0.26 (0.86)
Newar	5.53 (4.75)	5.53 (4.75)	1.18 (1.88)	1.80 (1.91)	1.80 (1.91)	0.30 (0.66)	2.20 (2.23)	2.15 (2.24)	0.29 (0.67)
Janajati	5.30 (4.71)	5.25 (4.68)	1.41 (2.00)	1.78 (2.12)	1.73 (2.10)	0.14 (0.37)	2.22 (2.68)	2.00 (2.50)	0.30 (0.85)
Muslim	2.72 (2.93)	2.72 (2.93)	0.58 (1.14)	1.28 (1.74)	1.28 (1.74)	0.10 (0.31)	0.17 (0.41)	0.17 (0.41)	0.00 (0.00)

SD, Standard deviation
[a]dmf/DMF; Decayed, Missing or Filled Tooth
[b]d/D; Decayed Tooth
[c]pufa/PUFA; Pulp involvement, ulceration, fistula or abscess
[d]t-test
[e]One-way ANOVA
*p<0.05
**p<0.001

Table 3. Prevalence (%) of different components of pufa/PUFA index in relation to age group, gender, location, developmental region, ecological region, and ethnicity

Variables	5-6-year-olds				12-year-olds				15-year-olds			
	p	u	f	a	P	U	F	A	P	U	F	A
Gender												
Boys	43.2	0.0	10.8	10.8	7.0	0.0	0.5	0.5	13.0	0.0	0.5	1.4
Girls	38.4	0.6	7.9	9.1	8.0	0.0	0.0	1.5	17.1	0.6	1.1	2.3
Location												
Urban	39.9	0.0	8.70	19.2	7.9	0.0	0.0	0.9	14.6	0.5	0.5	2.3
Rural	40.9	0.6	10.2	10.8	7.0	0.0	0.5	1.0	15.2	0.0	1.2	1.2
Developmental Region												
Eastern	48.1	1.9	5.6	13.0	8.9	0.0	0.0	2.2	18.0	0.0	1.1	3.4
Central	32.1	0.0	6.2	2.5	6.5	0.0	0.0	2.2	8.2	0.0	0.9	1.8
Western	54.5	0.0	12.1	18.2	13.1	0.0	0.0	0.0	19.2	0.0	0.0	1.4
Mid-western	33.9	0.0	13.6	10.2	4.8	0.0	0.0	0.0	14.3	0.0	2.9	0.0
Far-western	38.8	0.0	10.0	8.8	3.5	0.0	1.2	0.0	17.1	0.0	0.0	1.3
Ecological Region												
Mountain	45.4	0.9	10.2	11.1	8.9	0.0	0.7	1.5	21.4	0.0	0.9	1.7
Hill	40.7	0.0	8.7	6.4	7.1	0.0	0.0	0.5	11.6	0.0	1.1	1.7
Tarai	33.3	0.0	10.0	18.3	6.0	0.0	0.0	1.2	12.9	1.2	0.0	2.4
Ethnic Group												
Brahaman/ Chhetri	42.6	0.0	11.9	9.1	4.4	0.0	0.5	1.0	17.1	0.6	0.0	1.7
Tarai Madhesi	27.3	0.0	0.0	9.1	0.0	0.0	0.0	5.6	7.4	0.0	0.0	0.0
Dalits	31.4	0.0	5.7	11.4	5.0	0.0	0.0	0.0	10.0	0.0	0.0	3.3
Newar	35.3	0.0	11.8	0.0	20.0	0.0	0.0	0.0	14.3	0.0	2.9	5.7
Janajati	44.7	1.1	7.4	12.8	12.3	0.0	0.0	0.8	15.5	0.0	1.8	0.9
Muslim	28.6	0.0	0.0	14.3	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

p/P; Pulp Involvement
u/U; Ulceration of the oral mucosa due to root fragments
f/F; Fistula
a/A; Abscess

Table 4. Mean number of teeth (SD) and prevalence of gingival bleeding on probing (BOP), dental traumas and fluorosis in relation to age group, gender, location, developmental region, ecological region, and ethnicity.

Variables	5-6-year-olds					12-year-olds					15-year-olds				
	Mean (SD) gingival bleeeding	Bleeding on probing		Dental Traumas (%)	Fluorosis (%)	Mean (SD) gingival bleeeding	Bleeding on probing		Dental Traumas (%)	Fluorosis (%)	Mean (SD) gingival bleeeding)	Bleeding on probing		Dental Traumas (%)	Fluorosis (%)
		BOP ≤ 15%	BOP > 15%				BOP ≤ 15%	BOP > 15%				BOP ≤ 15%	BOP > 15%		
Gender															
Boys	13.22 (4.85)	4.0	96.0	1.7	4.5	13.72 (6.55)	7.0	93.0	7.0	12.7	18.80 (6.40)	1.9	98.1	7.2	13.0
Girls	12.88 (4.90)	6.7	93.3	1.8	3.7	15.83 (6.33)	3.5	96.5	3.0	10.9	19.13 (6.78)	2.3	97.7	5.1	12.6
Location	***b				**a	***b		**a		**a	*b				**a
Urban	12.01 (4.84)	6.9	93.1	2.3	7.5	13.59 (6.92)	8.9	91.1	7.0	16.4	18.32 (6.72)	2.7	97.3	5.9	17.4
Rural	14.14 (4.67)	3.6	96.4	1.2	0.6	15.98 (5.82)	1.5	98.5	3.0	7.0	19.79 (6.29)	1.2	98.8	6.7	6.7
Developmental Region	***c		***a		**a	***c		***a		*a	***c				*a
Eastern	11.15 (3.49)	3.7	96.3	0.0	5.6	13.60(6.56)	8.9	91.1	2.2	15.6	17.31 (6.92)	4.5	95.5	6.7	16.9
Central	14.64 (4.08)	0.0	100.0	1.2	4.9	16.92(5.64)	1.1	98.9	7.6	13.0	21.15 (5.99)	0.9	99.1	7.3	7.3
Western	10.55 (6.25)	19.7	80.3	4.5	4.5	12.38 (7.48)	14.3	85.7	8.3	14.3	17.05 6.86)	2.7	97.3	4.1	17.8
Mid-western	15.05 (4.45)	1.7	98.3	0.0	5.1	15.40 (5.93)	1.6	98.4	1.6	9.7	18.89 (6.65)	2.9	97.1	0.0	5.7
Far-western	13.34 (4.09)	2.5	97.5	2.5	1.3	15.44 (5.88)	0.0	100.0	4.7	5.8	19.53 (5.68)	0.0	100.0	9.2	14.5
Ecological Region	***c		*a		***a	***c				***a			*a		***a
Mountain	15.44 (4.07)	0.9	99.1	0.0	0.0	16.81 (5.85)	1.5	98.5	2.2	8.9	20.16 (6.37)	0.0	100.0	5.1	8.5
Hill	12.29 (4.80)	6.4	93.6	2.3	3.5	14.18 (6.64)	7.1	92.9	5.6	7.7	18.31 (6.88)	4.4	95.6	7.2	7.2
Tarai	10.95 (4.78)	10.0	90.0	3.3	13.3	12.71 (6.42)	7.2	92.8	8.4	26.5	18.64 (5.97)	0.0	100.0	5.9	30.6
Ethnic Group					***a	**c		*a							***a
Brahaman/ Chhetri	13.54 (4.55)	4.5	95.5	1.1	1.1	13.56 (6.13)	5.9	94.1	8.4	11.8	18.70(6.45)	2.3	97.7	7.4	8.6
Tarai Madhesi	15.36 (3.78)	0.0	100.0	0.0	27.3	16.33 (5.99)	0.0	100.0	0.0	27.8	22.04 (5.56)	0.0	100.0	7.4	33.3
Dalits	13.03 (5.38)	5.7	94.3	2.9	5.7	17.48(5.93)	2.5	97.5	2.5	5.0	17.23 (6.12)	0.0	100.0	10.0	43.3
Newar	12.65 (5.07)	5.9	94.1	0.0	0.0	14.00 (8.71)	20.0	80.0	5.0	5.0	18.83(7.59)	8.6	91.4	2.9	11.4
Janajati	12.22 (5.29)	7.4	92.6	3.2	4.3	15.78(6.55)	4.1	95.9	1.6	12.3	19.24(6.67)	0.9	99.1	4.5	5.5
Muslim	9.57 (1.90)	0.0	100.0	0.0	42.9	13.55(7.41)	0.0	100.0	0.0	18.2	16.50(5.54)	0.0	100.0	0.0	33.3

SD, Standard Deviation

[a]χ- test

[b]t-test

[c]One-way ANOVA

*p<0.05

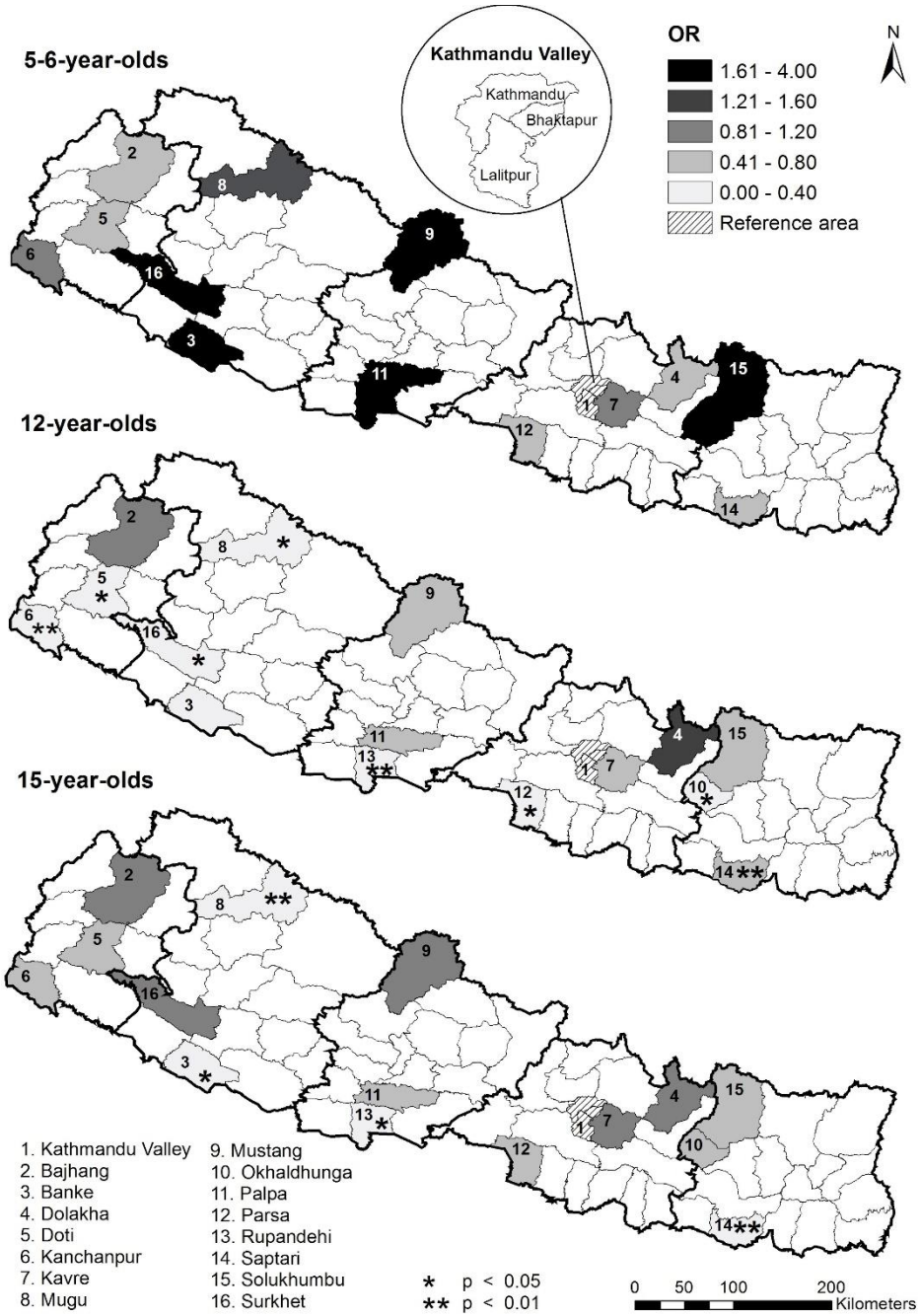
**p<0.01

***p<0.001

Table 5. Mean (SD) dental caries experience in relation to fluoride levels in drinking water.

Fluoride Level (ppm)	n	Number of Sample Sites	dt	dmf	DT	DMF
< 0.5	915	21	4.93 (4.27)	4.97 (4.31)	1.61 (2.03)	1.68 (2.10)
0.5 – 0.8	177	5	5.60 (3.89)	5.71 (4.04)	1.64 (2.14)	1.66 (2.16)
> 0.8	45	1	1.89 (2.53)	1.89 (2.53)	1.45 (2.08)	1.48 (2.16)
p-value			0.060	0.055	0.505	0.855

SD, Standard Deviation
dt/DT; Decayed Tooth
dmf/DMF; Decayed, Missing or Filled Tooth


5-6-year-olds
12-year-olds
15-year-olds
Kathmandu Valley
Kathmandu
Bhaktapur
Lalitpur
OR
1.61 - 4.00
1.21 - 1.60
0.81 - 1.20
0.41 - 0.80
0.00 - 0.40
Reference area
N
1. Kathmandu Valley
2. Bajhang
3. Banke
4. Dolakha
5. Doti
6. Kanchanpur
7. Kavre
8. Mugu
9. Mustang
10. Okhaldhunga
11. Palpa
12. Parsa
13. Rupandehi
14. Saptari
15. Solukhumbu
16. Surkhet
* p < 0.05
** p < 0.01
0 50 100 200
Kilometers