

# ORAL HEALTH AND ORAL HEALTH CARE PROMOTION IN NEPALESE SCHOOLCHILDREN (KERUNG, NEPAL): A SIX-MONTH FOLLOW-UP

Astrid Capoen, Deborah Depestel  
01207845, 01409604

Promoter: Prof. dr. L. C. Martens

A dissertation submitted to Ghent University in partial fulfilment of the requirements for the degree of Master of Science in Dentistry

Academic year: 2018 – 2019



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As many photographs were taken during the project, a visual representation of several events can be found under Addendum 1.

Astrid Capoen and Deborah Depestel

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## LIST OF ABBREVIATIONS

ART	Atraumatic Restorative Treatment
BEWE	Basic Erosive Wear Examination
DMFT/dmft	Decyad, missed and filled teeth
EAPD	European Academy of Paediatric Dentistry
e.g.	exempli gratia
H0	Null hypothesis
H1	Alternative hypothesis
ICDAS	International Caries Detection Assessment System
ISCO	International Standard Classification of Occupations
MIH	Molar-incisor hypomineralisation
N/A	Not applicable
NHRC	Nepal Health Research Council
OHRES	Oral Health data Registration and Evaluation System
OHRQoL	Oral health-related quality of life
PUFA	Pulpal involvement, Ulcerations, Fistulas, Abscesses
QoL	Quality of life
T0	Time point zero (first visit: 19/04/2018 - 7/05/2018)
T1	Time point one (second visit: 22/11/2018 - 7/12/2018)
TDI	Traumatic Dental Injuries
TF index	Thylstrup-Fejerskov index
WHO	World Health Organisation

# ABSTRACT

## Objectives

Firstly, the project aims to describe the present oral situation, knowledge about oral health, oral health habits, nutritional habits and oral health-related quality of life of the children in Kerung, a remote village in Nepal. Secondly, this project consists of a prospective evaluation of the previously mentioned data six months after giving an oral health promotion program and providing treatments.

## Materials and methods

A prospective case series was conducted. With a six-month interval, extensive epidemiological data was collected. A convenience sample was included in the study, consisting of the children from the local school in Kerung. At time point 0 (T0), 359 children with a mean age of 13.24 years old (range 2 - 22 years old) were examined and at time point 1 (T1), 339 children with a mean age of 13.14 years old (range 2 - 24 years old) were included in the study. During both visits the children were clinically examined and filled in three questionnaires. The screening consisted of validated indexes to evaluate the plaque, decay, clinical consequences of untreated decay, erosion, trauma, fluorosis and molar-incisor hypomineralisation. Developmental disorders and malocclusion were also noted. The three questionnaires respectively examined the oral health knowledge, oral health habits and oral health-related quality of life of the children. Aside from the data collection, an oral health promotion program was developed, emphasizing prevention by teaching adequate oral health habits, both theoretically and practically. When pathology was found during the screening, this was treated by the Nepalese dental team. Glass ionomer fillings were placed and when necessary, extractions were performed. At T1, materials for removal of calculus were provided. The 266 children seen at T0 as well as at T1 were included in the paired prospective part of the study. These children had a mean age of 12.88 years, ranging from minimum 2 years old up to maximum 20 years old.

## Results

At T0, the examined children showed a caries prevalence of 79.0%. The mean DMFT/dmft was 9.16 and was dominated by the decayed component. A high treatment need was observed. The mean plaque score was 0.77. The general knowledge about oral health was low. In contrast, the children showed a positive attitude towards oral health. Of the examined children, 76.4% reported to brush at least twice a day and 81.9% stated to brush at least two minutes. 58.8% of the children claimed to eat a sugar-containing snack at least once a day,

while 16.2% claimed to eat at least one piece of fruit daily. Respectively 45.7% and 33.2% of the children reported to drink at least one unit of soft drinks or fruit juice a day. More than half of the questioned children (61.4%) declared to have experienced toothache or oral pain in their life before. At T1, 38.7% of the children presented with calculus. Drinking sugary tea daily was done by 41.7%. Knowledge about oral health was obtained from several sources, including schoolteachers, parents and the media.

A statistically significant decrease in the mean plaque score was measured after the oral health promotion program. The mean reduction turned out to be higher for boys than for girls. A significant decrease was observed in caries prevalence, as well as a significant increase in knowledge about oral health. At T1, a significantly higher percentage of children was measured brushing their teeth for at least two minutes.

### Conclusion

A high caries prevalence and low oral cleanliness were present in the children in Kerung. A negligible amount of erosion, untreated dental trauma, fluorosis, molar-incisor hypomineralisation, developmental disorders and malocclusion was encountered. Insufficient knowledge about oral health, inadequate brushing habits and nutritional habits were found. A clear effect of this collected data on quality of life was not found.

Dental screenings, treatments and a comprehensive educational program proved to possibly have a significant influence on oral health, especially reflected in a statistically significant decrease in plaque and caries prevalence.

# 1. INTRODUCTION

## 1.1 Oral health

Oral health is described as a significant part of overall health, which has an influence on the quality of life (QoL) and well-being of an individual. According to World Health Organization (WHO), oral health is defined as “a state of being free from chronic mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual’s capacity in biting, chewing, smiling, speaking and psychosocial wellbeing” (1).

The emphasis of WHO on oral health is mainly put on prevention and oral health promotion, as it is seen that oral problems often originate in the incapacity to appropriately perform oral hygiene (2). Evidence from numerous studies shows that oral health problems still affect people around the world, specifically in developing and underdeveloped countries (1, 3-26).

Dental caries is one of the main issues among oral health problems. WHO reports that 60-90% of schoolchildren globally have experienced dental caries and it is reported that there is a high prevalence in Asia (10-12, 18, 19, 21, 27). In this respect, the Nepal National Oral Health Pathfinder Survey of 2004 reported that 57.5% of the Nepalese 5 to 6-year-olds had dental caries (26).

## 1.2 Nepal and Kerung

Nepal is an Asian country situated north of India and south of China. Kathmandu is the capital of Nepal. Nepal has an acreage of 147.181 km<sup>2</sup>, which is approximately five times the size of Belgium. There are no seas adjacent to the country. In the north, Nepal is bordered by the Himalayan mountains. Eight of the fourteen highest mountains in the world are situated in Nepal, of which the Mount Everest is the highest mountain on Earth (8848 meters). Nepal is divided into five regions, which consists of fourteen zones, which are divided into 75 districts (24, 28). According to data from 2018, Nepal is the 30<sup>th</sup> poorest country in the world (29).

According to the population estimates based on interpolation of the World Population Prospects data, there are about 29.89 million citizens in Nepal in 2019. The annual growth rate of the population in 2019 is estimated to be 1.07%. There is a population projection for 2025 of 31.81 million inhabitants, thus an increase in population is expected (Figure 1.1) (28). The gender ratio is approximately 1/1.06, with a slightly higher portion of females.

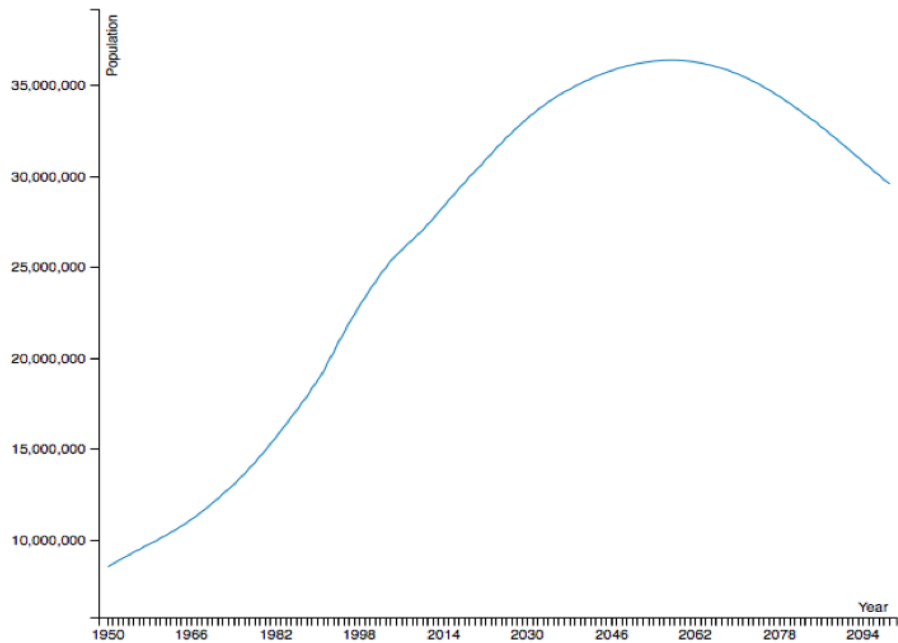


Figure 1.1 Estimated growth population of Nepal - Population Data Nepal via United Nations World Population Prospects (2015) (28).

The age distribution in Nepal (30) is divided as shown in figure 1.2. It is obvious that the younger population comprises a big proportion of the total population. The age group under 20 years old makes up the biggest part of the entire population.

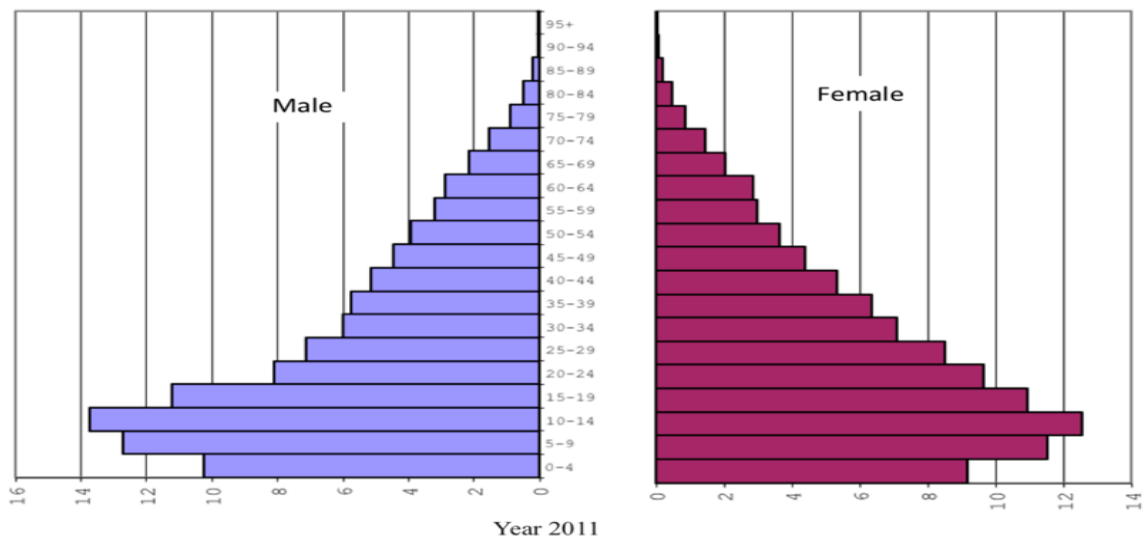


Figure 1.2 Population pyramid 2011 of the Nepalese population (30).

In 2018, the life expectancy in Nepal was 68 years for males and 73 years for females, while in developed countries it was respectively 76 and 82 years. It can be concluded that the life expectancy of Nepalese people is lower than in the developed world (30, 31).

There are a variety of religions present in Nepal, of which Hinduism and Buddhism are the dominant ones. Islam, Kirat, Christianity and other smaller religions are also professed in Nepal. Nepal uses a caste system as a hierarchical social stratification. As noted in the census of 2011, there are 125 caste groups in Nepal (30). Aside of the official Nepalese language, 122 languages are spoken in Nepal (16, 28, 30, 32-35).

An earthquake struck Nepal on the 25<sup>th</sup> of April 2015. This earthquake, also known as the Gorkha earthquake, with a magnitude of 7.8 on the Richter scale, killed more than 8000 people and injured more than 21 000 people. A large part of Nepal was destroyed, nearly three million people were made homeless (36, 37).

Kerung is a remote village situated in the Solukhumbu District, in the north-east of Nepal. It is only accessible by a small and bumpy track through the woods. Kerung has about 4500 inhabitants. Approximately 80% of them maintain themselves through agriculture. Hinduism is the most prominent religion practised by the Kerung inhabitants.

Kerung is the only village in the area which has a governmental school providing primary as well as secondary education. The school was set up in 1956 and is situated in the centre of the village. In 2018, eighteen teachers were employed. School is mandatory for children from age 5 until the age of 18, but a lot of children in Kerung do not go to school on a daily basis and work on the fields for their family instead. Some children have to walk twice daily for two hours to go to school. Very few children continue to higher education (Addendum 2.1).

The Gorkha earthquake also had its effect on Kerung. There was a lot of damage to the village, which is now still being rebuilt. Some people even have problems with their homes up until today. The Kerung school was also affected. For instance, the hostel nearby the school, providing shelter to the children living far from the school on weekdays, was completely demolished (Addendum 2.1).

### [1.3 Oral health in Nepal and Kerung](#)

There are thirteen dental schools in Nepal and every year 500 to 600 students graduate as dentist, but in a developing country such as Nepal, oral health typically has a low political priority. The government of Nepal does not provide enough jobs, which leads to a lot of competitiveness and a large unemployment rate among dentists in Nepal (Addendum 2.2). In 2015, a total of 1803 Nepalese dentists were registered in Nepal. Among the 1047 professionally active dentists, 601 (57,4%) were working in the Kathmandu Valley and 446

(42,6%) were working outside the Kathmandu valley. The Kathmandu valley is the area around Kathmandu (38, 39).

The headmaster of the local school in Kerung stated there are no oral health services available in Kerung. The nearest dentist is located in Phaplu, the headquarter of the Solukhumbu District. Taking into account the cost regarding transport from Kerung to Phaplu and the cost for dental check-up or treatment, receiving oral health care is unaffordable for most citizens of Kerung (Addendum 2.1).



## 2. LITERATURE

A literature search was performed to establish a basic knowledge about the subject and to investigate what research was already done about the matter. The search was performed using a structured search strategy. Four medical scientific databases were used including Pubmed, Embase and Web of Science. Google Scholar was used as support. The articles found were filtered using predetermined inclusion and exclusion criteria (Table 2.1).

*Table 2.1 Inclusion and exclusion criteria of the study.*

Inclusion criteria	Exclusion criteria
Nepal (no other developing countries)	Pathology not situated in the oral cavity
Children (no adults)	Only abstract available
Oral health (including plaque, decay, erosion, trauma, fluorosis, molar-incisor hypomineralisation, developmental disorders, malocclusion, calculus and periodontitis)	
Oral health knowledge	
Oral cleanliness	
Nutritional habits	
Oral health-related quality of life	

The search in Pubmed was conducted by combining the following search terms using the Boolean operator 'AND': 'Oral health' [MeSH], 'Nepal' [MeSH], 'Nepal' (all fields) and 'Children' [MeSH]. Based on the inclusion and exclusion criteria, ten relevant articles were selected out of the Pubmed database. The literature searches in Web of Science and Embase were conducted using the same search pattern, based on the search terms 'Nepal', 'Oral health' and 'Child'. The search terms were combined using the Boolean operator 'AND'. After removing the articles which did not meet up to the predetermined inclusion and exclusion criteria, respectively seven and fourteen articles were withheld from the Web of Science database and Embase. After removal of the duplicates and adding three more articles, which were found in references of the collected data, a total number of 29 relevant articles were included in the literary review prior to the project. In figure 2.1 a flowchart provides a structured overview of the literature search, whereas table 2.2 gives a brief overview of the found articles.

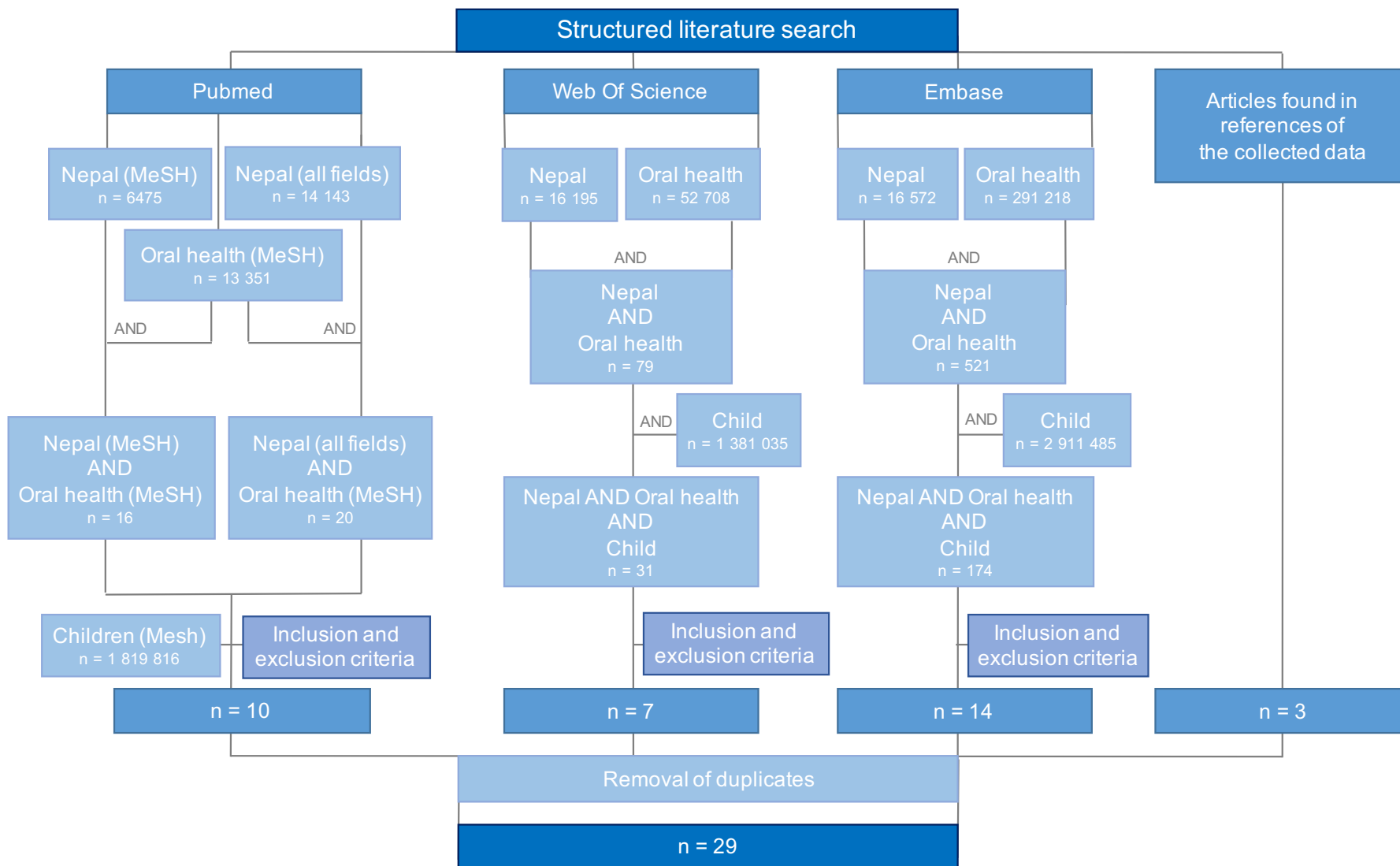


Figure 2.1 Flowchart showing the used search strings and results of the structured literature search and selection procedure.

According to present literature, the caries prevalence in Nepal is between 25.6 and 67.0% (1, 3-6, 8-10, 12-16, 18-23, 26, 40, 41). The DMFT/dmft varied from 0.20 to 4.00 (3, 5, 6, 8, 10, 16, 19, 21, 23, 26) and is mostly dominated by the decayed component (1, 6, 8, 10). There is a parallel increase in DMFT/dmft with increasing age (6). As addressed by Prasai Dixit et al. (2013) (10): "Nutritional transition with easy access to refined carbohydrates, low use of fluoridated toothpaste and irregular tooth brushing habits lead to increasing trend in dental caries in developing countries."

Helderman et al. (1998) (7) investigated the periodontal health of children between 12 and 19 years old and calculus was found in 68.0-97.0% of the children. In a more recent study performed by Knevel et al. (2008) (13), the Buddhi Banghara Project, 50.0% of the examined children aged 5 to 12 years old presented with calculus. Yee et al. (2009) (24) also reported a decrease in healthy sextants with an increase in age among schoolchildren when screened for calculus.

In 2014, Shakya et al. (19) reported that 36.5% of the 6 to 11-year-olds and 58.3% of the 12 to 16-year-old children had experienced oral pain in the previous year. According to other studies, approximately half of the questioned children had experienced oral pain before (1, 5, 10, 13). Fukai et al. (2012) (5) reported that 77.4% of the investigated children visited a dentist when having pain, while only 5.6% got a regular check-up.

The brushing behaviour is extensively reviewed in the found articles. A large part of the Nepalese population accepts brushing once a day as standard norm and a smaller percentage, between 16.9 and 36.9%, brushes twice a day (4, 5, 8, 10, 13, 22, 38). Different studies (1, 8-10, 19, 22, 26, 38) reported that between 65.0 and 86.1% of the questioned children uses toothpaste when brushing their teeth.

There is a relatively low consumption of sugar in Nepal in comparison to the western world (1). Although, as a result of tourism, some communities are exposed to the western lifestyle and adopt the corresponding dietary pattern. Studies showed that the sugar consumption in Nepal is mostly confined to the ingestion of sugary tea during the day (5, 22, 40). In some articles it is cited that in Nepal there is a habit to rinse the mouth with water after a meal (8, 10).

In Nepal, there is a lack in accessibility of health care. There is a shortage of availability of affordable health services such as dental care (3, 5, 8, 10, 12, 18, 40). In a study conducted by Prasai Dixit et al. (2013) (10) in five primary schools, 93.0% of the children has never been to a dentist. The research of Fukai et al. (2012) (5) stated that the participants, 829 children

from 3 to 16 years old, have limited access to dental treatments. This can be seen in the DMFT/dmft scores, which are dominated by the decayed component and have low values for the missed and filled component. The high need for treatment is also discussed in other articles (3, 8, 10, 12).

The fluoridation project by Yee et al. (2003) (9) is one of the most important studies conducted in Nepal. The comprehensive program was designed to raise the availability and consumption of affordable fluoridated toothpaste in Nepal and to consequently reduce the caries prevalence. Before the fluoridation project in 1997, the amount of fluoridated toothpaste in Nepal was negligible. With the completion of the project, the market share of fluoridated toothpaste was raised to 90.0%. The long-term impact was investigated six years after the completion of this thorough fluoridation project and showed a statistically significant improvement in supply and usage of fluoridated toothpaste in Nepal. As a result, a significant decrease in pain in 12 to 13-year-olds was noticed (1).

In several articles a lack of knowledge regarding oral health was observed in the Nepalese population (1, 3-6, 8-10, 12-16, 18-23, 40, 41). The knowledge about the importance of fluoride is often discussed in literature and awareness of the importance of fluoride seems to be very limited in Nepalese children (10, 13). In the study conducted by Prasai Dixit et al. (2013) (10), it is stated that 82.0% of children in five participating primary schools in Nepal did not know what fluoride is or what its influence means on oral health. It is recommended in the literature to raise the awareness about the importance of oral health at a young age (5, 15, 19, 22, 24, 26, 42).

During childhood, parents have the greatest influence on the health of their children. Habits are shaped by the information given by parents. They are the primary social force to influence the children (8). Media was also found to be a source of oral health information. Next to parents and media, research by several sources lists teachers as an important and effective source of oral health information for school aged children (5, 11, 19, 21-23, 26, 43).

Schools are suggested as an effective platform for oral health promoting education (5, 10, 19-22, 24, 26, 42) and follow-up is recommended (38). A study conducted by Helderman et al. (1999) (7) recommended to put emphasis on providing oral health education and emergency treatments in developing countries. Other studies confirmed that oral health care should focus more on prevention and oral health promotion through education (5, 10, 15, 26, 42, 44) rather than on treatment of its consequences, which a lot of people in developing countries such as Nepal cannot afford (3, 7, 8, 12, 13, 22, 38).

In summary, there is a substantial amount of studies conducted about Nepal and the oral health of its inhabitants. Most of the available studies have some shortcomings, as cited below.

1. Most of the conducted studies focus on collecting cross-sectional descriptive data, only two of the implemented studies conduct a prospective investigation (1, 41).
2. The examination of oral health in literature is limited, as in most of the articles the main focus is put on decay, oral hygiene behaviour and dietary habits of the Nepalese people. No further analysis is done about other important determinants of oral health, such as the presence of infection, erosive dental tooth wear, history of dental trauma or developmental disorders.
3. Caries prevalence in literature is mostly described by using DMFT/dmft without any further investigation of the severity of present decay and the consequences of untreated dental caries.

Table 2.2 Overview of the articles included in the literature review.

(Level of evidence is noted according to Sutherland (2001) (45), N/A = not applicable, y = years old)

<b>Title</b>	<b>Author</b>	<b>Year of publication</b>	<b>Study design</b>	<b>Sample</b>	<b>Level of evidence</b>
<b>Oral health status of 12-year-old children in Nepal in 1994</b>	Milsom, K. et al.	1997	Cross-sectional study	n = 360 (12 y)	4
<b>Analysis of epidemiological data on oral diseases in Nepal and the need for a national oral health survey</b>	Helderman, WvP. et al.	1998	Literature review	N/A	4
<b>Integrating oral health into primary health care - experiences in Bangladesh, Indonesia, Nepal and Tanzania</b>	Helderman, WvP. et al.	1999	Literature review	N/A	4
<b>An ART field study in western Nepal</b>	Yee, R.	2001	Prospective case series	n = 105 (3-19 y)	4
<b>Caries experience of 5-6-year-old and 12-13-year-old schoolchildren in central and Western Nepal</b>	Yee, R. & McDonald, N.	2002	Cross-sectional study	n = 2177 (5-6 y), n = 3323 (12-13 y)	4
<b>An advocacy project to fluoridate toothpastes in Nepal</b>	Yee, R. et al.	2003	Advocacy project	N/A	N/A
<b>National Oral Health Pathfinder Survey Nepal</b>	Yee, R. & Mishra, P.	2004	Cross-sectional study	n = 1027 (5-6 y), n = 1047 (12-13 y), n = 1074 (15-16 y)	4
<b>Hygiene, eating habits and oral health among children in three Nepalese Public High Schools</b>	Westbacke, K.	2006	Cross-sectional study	n = 231 (5-16 y)	4
<b>Gains in oral health and improved quality of life of 12-13-year-old Nepali schoolchildren: outcomes of an advocacy project to fluoridate toothpaste</b>	Yee, R. et al.	2006	Follow-up advocacy project	n = 1047 (12-13 y)	4

<b>Oral cleanliness of 12-13-year-old and 15-year-old school children of Sunsari District, Nepal</b>	Yee, R. et al.	2006	Cross-sectional study	n = 600 (12-13 y), n = 600 (15 y)	4
<b>Buddhi Bangara Project on oral health promotion</b>	Knevel, R.J.M. et al.	2008	Cross-sectional study	n = 309 (5-12 y)	4
<b>A Himalayan dental adventure!</b>	Bhuva, S.	2009	Expert opinion	n = 650	5
<b>The periodontal health of Nepalese schoolchildren</b>	Yee, R. et al.	2009	Cross-sectional study	n = 1025 (5-6 y), n = 1037 (12-13 y), n = 1053 (15-16 y)	4
<b>Training rural women to improve access to oral health awareness programmes in remote villages in Nepal</b>	Knevel, R.J.M.	2010	Cross-sectional study	n = 141	4
<b>Determinants and promotion of oral hygiene behaviour in the Carribean and Nepal</b>	Buunk-Werkhoven, Y.A.B. et al.	2011	Cross-sectional study	n = 221	4
<b>Evaluation of knowledge, attitude and practice (KAP) about oral health among secondary level students of rural Nepal – A questionnaire study</b>	Humagain, M.	2011	Cross-sectional study	n = 1000 (13-18 y)	4
<b>Prevalence of dental caries in 5-6 years and 12-13 years age group of school children of Kathmandu valley</b>	Subedi, B. et al.	2011	Cross-sectional study	n = 313 (5-6 y), n = 325 (12-13 y)	4
<b>Oral Health Status and Oral Health Behavior of School Children in Central Nepal</b>	Fukai, K. et al.	2012	Cross-sectional study	n = 829 (3-16 y)	4
<b>Dental caries prevalence, oral health knowledge and practice among indigenous Chepang school children of Nepal.</b>	Prasai Dixit, L. et al.	2013	Cross-sectional study	n = 131 (8-16 y), n = 361 (5-16 y)	4

<b>Prevalence of dental caries among public school children in Eastern Nepal</b>	Bhagat, TK. & Shrestha, A.	2014	Cross-sectional study	n = 666	4
<b>Dental caries status and oral health practice among 12-15 year old children in Jorpati, Kathmandu</b>	Khanal, S. & Acharya, J.	2014	Cross-sectional study	n = 252 (12-15 y)	4
<b>Oral health related knowledge, attitude, and practice among school children of Jyamrung, Nepal.</b>	Shakya, A. et al.	2014	Cross-sectional study	n = 88 (6-16 y)	4
<b>Occurrence of dental caries in primary and permanent dentition, oral health status and treatment needs among 12-15 year old school children of Jorpati VDC, Kathmandu</b>	Shrestha, N. et al.	2014	Cross-sectional study	n = 366 (12-15 y)	4
<b>Prevalence of Molar Incisor Hypomineralisation Among School Children in Kavre</b>	Shrestha, R. et al.	2014	Cross-sectional study	n = 749 (7-12 y)	4
<b>Assessment of knowledge regarding oral hygiene among parents of pre-school children attending pediatric outpatient department in Dhulikhel Hospital</b>	Khanal, K. et al.	2015	Cross-sectional study	n = 100	4
<b>Oral health condition of school children in Nawalparasi District, Nepal</b>	Thapa, P. et al.	2015	Cross-sectional study	n = 357 (5-6 y), n = 469 (12-13 y)	4
<b>Prevalence of dental caries and oral hygiene practice in school children of Bhaktapur, Nepal</b>	Suttagul K. et al.	2016	Cross-sectional study	n = 340 (4-15 y)	4
<b>Prevalence of Dental Caries among Primary School Children of Kathmandu District - A pilot study</b>	Khanal, S. et al.	2017	Cross-sectional study	n = 468 (5-15 y)	4
<b>Significant caries index evaluation of dental caries among preschool children in Kathmandu</b>	Limbu, S. et al.	2017	Cross-sectional study	n = 1445 (3-6 y)	4



### 3. OBJECTIVES OF THE STUDY

In the present literature, there were almost no studies available with a prospective study design. Most of the previously executed studies were cross-sectional observations of the present problems in combination with an educational program teaching the children the essential knowledge and proper oral health behaviour. Almost none of the studies evaluated the effectiveness of the executed educational program. From the present review, it could be seen that often only decay, described according to DMFT/dmft, oral hygiene behaviour and dietary habits were investigated. Further specification regarding consequences of dental caries or other oral health problems were rarely included and reported. A more complete representation of the entire oral health status can be obtained by including a broader range of indexes.

Taking into account the lacunas found in literature, two main goals for the present prospective study could be developed. The first goal was to conduct a cross-sectional baseline study (T0) to examine the current oral health situation in all aspects, as well as the current level of oral health knowledge, the oral health habits and the oral health-related quality of life (OHRQoL) of the children in Kerung. The second goal was to conduct a prospective study (T1) evaluating the evolution of the same parameters six months after providing the children with an oral health promotion program. The program was mainly focussed on prevention, in order to raise the knowledge about oral health and to teach the children how to maintain proper oral health.

These two aims could be formulated in two PICO questions.

1. Cross-sectional study:

What is the current status of the oral health, oral health knowledge, oral cleanliness, nutritional habits and OHRQoL (O) of schoolchildren (P) in Kerung, a remote village in Nepal?

2. Prospective study:

Will oral health promotion, instruction and treatments (I) lead to a better oral health, oral health knowledge, oral cleanliness, nutritional habits and OHRQoL (O) in children from 2 to 25 years old in the Nepalese village Kerung (P) compared to the status six months before (C)?

A null hypothesis (H0) and an alternative hypothesis (H1) were composed as a part of the prospective study.

H0 Six months after giving the children oral health education and treatment there will be a positive effect on the oral health and/or oral health behaviour.

H1 Six months after giving the children oral health education and treatment there will be no positive effect on the oral health and/or oral health behaviour.

The oral health takes quantity of plaque, caries prevalence and pathology as a consequence of untreated dental caries into account. The oral health behaviour takes oral health knowledge, oral health habits, nutritional habits and OHRQoL into account.

The feasibility of the project was checked through the SMART principle (Addendum 3).

## 4. MATERIALS AND METHODS

### 4.1 Surveyed population and sampling method

A prospective study with a six-month follow-up was conducted in a local primary school in Kerung. Before conducting the study, approval was obtained from the Ethical Committee of the University Hospital of Ghent (Belgium) and the Nepal Health Research Council (NHRC) (Addendum 4). Convenience sampling was used as the project was restricted to the Kerung School. Informed consent was received from the headmaster of the school and parental consent was obtained prior to the field work (Addendum 5). Only the children with parental consent were included in the study. All students were identified through school records and an identification number was assigned to every child.

### 4.2 Clinical information collected in screening

The baseline data was collected in April 2018 (T0) (Figure 4.1) and could be considered as a cross-sectional, descriptive part of the study, which consisted of clinical examinations and questionnaires. The clinical examination covered several domains of the oral health status and was carried out as much as possible according to validated indexes. The values were noted on a screening sheet, which allowed the teams to screen in a systematic and structured way. The used screening format was developed according to the suggestions of WHO (46) and is added under Addendum 6.1.1.

The follow-up data was gathered in November 2018 (T1) (Figure 4.1). For this prospective part of the study, the clinical examinations and questionnaires were repeated. During the second visit the intra-oral examinations were restricted to the oral health parameters which could have changed: plaque, caries prevalence and clinical consequences of untreated caries. The detection of calculus was also added in the clinical examination. The used screening format is added under Addendum 6.1.2.

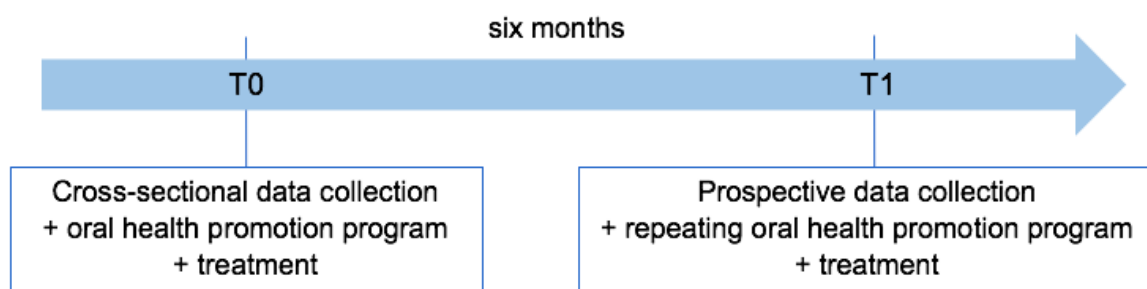


Figure 4.1 Timeline of the study: visual representation.

#### 4.2.1 Plaque – Plaque index (46)

The plaque index, as introduced by Sillness & Loë in 1964 and more fully described by Loë in 1967 (47), was used to measure the plaque present on the buccal side of the Ramfjord teeth. A score from zero to three was given (Table 4.1) and the mean plaque score was calculated and could be considered as a measure to visualize the efficiency of the present tooth brushing habits in the Kerung schoolchildren.

*Table 4.1 Criteria for the plaque index, according to Loë, 1967 (47).*

Plaque index	
0	No plaque in the gingival area.
1	A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may only be recognized by running a probe across the tooth surface.
2	Moderate accumulation of soft deposits within the gingival pocket, on the gingival margin and/or adjacent tooth surface, which can be seen by the naked eye.
3	Abundance of soft matter within the gingival pocket and/or the gingival margin and adjacent tooth.

#### 4.2.2 Decay – caries prevalence – ICDAS (48) & DMFT/dmft (49)

As recommended by WHO (29), the use of International Caries Detection Assessment System (ICDAS), described by Gugnani et al. (2011) (48), is an appropriate evidence-based clinical scoring system in epidemiology. The two-digit coding method was used for measuring the incidence of caries and its severity, as well as evaluating the state of existing restorations. The first digit identifies the presence of restorations and/or sealants. The second digit reports the occurrence of dental caries (Table 4.2). All surfaces of each present tooth were examined.

Because of its worldwide acceptance and the possibility to compare with the results of previous epidemiological studies, the measured ICDAS scores were translated into matching DMFT/dmft scores (27, 49). The decayed component was derived from the second digit of the measured ICDAS score. ICDAS score 0 was reported as  $D_0/d_0$ , ICDAS score 1 and 2 were reported as  $D_1/d_1$ , ICDAS score 3 was noted as  $D_2/d_2$  and ICDAS score 4, 5 and 6 were seen as  $D_3/d_3$ . Teeth which were assigned a  $D_3/d_3$  score were considered as carious lesions in need for treatment. Also missed (M/m) and filled (F/f) teeth were noted. Capital letters are used to score the permanent dentition and lowercase letters are used for the primary dentition.

Table 4.2 ICDAS codes and criteria, according to Gugnani et al., 2011 (48).

International Caries Detection Assessment System			
First digit		Second digit	
0	Sound, surface not restored or sealed	0	Sound surface: No evidence of caries after 5 seconds air drying
1	Sealant, partial	1	First visual change in enamel: Opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure seen after prolonged air drying
2	Sealant, full	2	Distinct visual change in enamel visible when wet, lesion must be visible when dry
3	Tooth coloured restoration	3	Localized enamel breakdown (without clinical visual signs of dentinal involvement) seen when wet and after prolonged drying
4	Amalgam restoration	4	Underlying dark shadow from dentine
5	Stainless steel crown	5	Distinct cavity with visible dentine
6	Porcelain or gold or porcelain fused to metal crown or veneer	6	Extensive (more than half the surface) distinct cavity with visible dentine
7	Lost or broken restoration		
8	Temporary restoration		
9	Used for the following conditions: 96 Tooth surface cannot be examined: surface excluded 97 Tooth missing because of caries 98 Tooth missing for reasons other than caries 99 Unerupted		

Two indices, derived from the DMFT/dmft, were calculated to assess the proportion of treated carious lesions, ranging from 0 to 100%. The care index was calculated to estimate the proportion of teeth which had received restorative care. This index was calculated by dividing the filled component by the DMFT/dmft and multiplying this value by 100. The treatment index was calculated by dividing the sum of the missed and filled component by the DMFT/dmft and multiplying this value by 100. A subtle nuance can be found between these two indices. The care index does not consider tooth extraction as a solution, but as a part of the problem, while the treatment index proposes tooth extraction as a part of the solution, because it removes a (potential) focus of infection.

### 4.2.3 Clinical consequences of untreated dental caries – PUFA (17)

The presence of oral problems resulting from untreated dental caries is quantified by the PUFA index, described by Monse et al. (2010) (17). The index is easy to use and provides relevant information complementary to the used DMFT/dmft index (49). The PUFA index records severely decayed teeth with visible pulpal involvement, ulceration of the oral mucosa due to tooth or root fragments, fistulas and abscesses respectively with P/p, U/u, F/f, A/a. (Table 4.3). This is a score on tooth level. Independent of the kind of infection or pathology (P/p, U/u, F/f or A/a) the score reports the PUFA for permanent teeth (ranging from 0 to 32) and/or the pufa for primary teeth (ranging from 0 to 20).

Table 4.3 PUFA index, according to Monse et al., 2010 (18).

PUFA index	
P/p	Visible pulpal involvement
U/u	Ulceration caused by dislocated tooth or root fragments
F/f	Fistula
A/a	Abscess

### 4.2.4 Erosive tooth wear – BEWE (50)

To report the appearance and severity of erosive tooth wear, the Basic Erosive Wear Examination (BEWE) was used. Each child was given a total score, representing the sum of the most affected surface in each sextant as scored by the criteria described by Bartlett et al. in 2008 (50) (Table 4.4).

Table 4.4 BEWE criteria, according to Bartlett et al., 2008 (50).

Basic Erosive Wear Examination	
0	No erosive tooth wear
1	Initial loss of surface texture
2	Distinct defect, hard tissue loss < 50% of the surface area (dentin is often involved)
3	Hard tissue loss $\geq$ 50% of the surface area (dentin is often involved)

### 4.2.5 Untreated dental trauma – TDI (51)

Untreated dental trauma was assessed according to the Traumatic Dental Injuries (TDI) index as classified by Andreasen et al. in 2018 (51) (Table 4.5). Only trauma on the primary and permanent incisors was reported.

Table 4.5 Diagnostic index for untreated dental trauma, according to Andreasen et al., 2018 (51).

Traumatic Dental Injuries	
1	No untreated dental trauma, no injury
2	Treated dental injury
3	Enamel fracture only
4	Enamel-dentin fracture
5	Enamel-dentin fracture including pulp involvement
6	Missing tooth due to trauma

#### [4.2.6 Fluorosis – Thylstrup-Fejerskov \(52\)](#)

The Thylstrup-Fejerskov index (TF index) was included in this study to report the presence of fluorosis and distinguish the difference in its severity (52). The index contains ten scores designed to characterize the degree of dental fluorosis (Table 4.6). In this study, one overall score based on this TF index was attributed to the mouth, representing the most severe affected surface seen in the mouth.

Table 4.6 TF index and its criteria, according to Thylstrup and Fejerskov, 1978 (52).

Thylstrup-Fejerskov index	
0	Normal creamy surface after drying
1	Faint white lines
2	Distinct white lines, with some merged
3	Cloudy opacities with white lines in between
4	Paper white opacities on entire surface
5	Pitted and opaque surface
6	Merged pits form rows < 2 mm high
7	Irregular pattern of enamel loss < 1/2
8	1/2 surface enamel lost, remaining enamel being opaque
9	Cervical rim of opaque enamel

#### [4.2.7 MIH – EAPD guidelines \(53\)](#)

The presence of molar-incisor-hypomineralisation (MIH) as well as its severity were reported following the guidelines as described by the European Academy of Paediatric Dentistry (EAPD) in 2010 in Helsinki (53). A distinction was made between mild and severe MIH (Table 4.7). In this study, the incisors and the first molars of the permanent and primary dentition were screened.

Table 4.7 MIH, according to EAPD Guidelines, 2010 (53).

MIH	
Mild	Demarcated enamel opacities without enamel breakdown. Occasional sensitivity to external stimuli e.g. air/water but not brushing. Only mild aesthetic concerns on discolouration of the incisors.
Severe	Demarcated enamel opacities with enamel breakdown. Caries, persistent/spontaneous hypersensitivity affecting function e.g. during brushing. Strong aesthetic concerns that may have socio-psychological impact.

#### 4.2.8 Developmental disorders

When the presence of any form of developmental disorder was noticed in the examined children, such as dental fusion, tooth gemination, peg-shaped tooth, dens evaginatus and invaginatus, enamel hypoplasia, the presence of a mesiodens, hypodontia and microdontia, this was noted on the screening sheet.

#### 4.2.9 Malocclusion

In children older than 12 years, the horizontal and vertical anterior malocclusion was measured by asking them to close their mouth in maximal occlusion and using a periodontal probe for measuring. The horizontal anterior occlusion was referred to as normal, except when there was an inverse sagittal overjet or an increased sagittal overjet of six millimetres or more. The vertical anterior occlusion was noted as normal, except when there was an open bite or a vertical overbite of five millimetres or more.

#### 4.2.10 Calculus

The presence of calculus on all tooth surfaces of the present teeth was scored at T1. Patients could be referred for immediate calculus removal.

### 4.3 Clinical examination

#### 4.3.1 Personnel

##### 4.3.1.1 Team from Belgium

The clinical examinations were performed in pairs by two staff members of the Paediatric Dentistry Department and two master students of the University of Ghent.



#### 4.3.1.2 Team from Nepal

The Nepalese team who performed the treatments consisted of three Nepalese dentists and two dental assistants. During both stays, some staff members of Kathmandu Bir Hospital completed the team.

#### 4.3.2 Calibration of the examiners

The four examiners were trained and calibrated before every visit to score as unambiguously and correctly as possible. The Cohen's kappa values for the first and second visit with corresponding scores according to Fleiss and Landis & Koch can be found in Table 4.8 (54, 55).

*Table 4.8 Cohen's kappa values of the examiners with corresponding Fleiss and Landis & Koch scores (54, 55).*

<b>First visit</b>			
	Range kappa	According to Fleiss	According to Landis & Koch
<b>ICDAS</b>			
Inter-rater agreement	0.598 – 0.820		Moderate - Almost perfect
Intra-rater agreement	0.621 – 0.871	Intermediate to good - Excellent	
<b>BEWE</b>			
Inter-rater agreement	0.409 – 0.787		Moderate - Substantial
Intra-rater agreement	0.705 – 0.957	Intermediate to good - Excellent	
<b>Second visit</b>			
<b>ICDAS</b>			
Inter-rater agreement	0.685 – 0.859		Substantial - Almost perfect
Intra-rater agreement	0.762 – 0.859	Excellent	

#### 4.3.3 Physical arrangements

Kerung school provided two rooms: one room to create a temporary dental examination set-up and another room used as treatment site. The examination took place in a well-lit room using natural light as well as light adapted on the mirror. The Belgian team brought all necessary equipment and sterilizing materials. Dental probes (sharp and blunt), mouth mirrors, gauze, gloves and mouth-masks were provided by them.

The children were positioned on a chair, while the examiner viewed the mouth standing behind the child. For analysing the presence of malocclusion, the subject was looked at in profile.

Gloves were worn throughout the examination and changed after every subject. A mouth mask was worn as well and changed every half a day or when filthy. The teeth were examined using a plane mouth mirror and a blunt probe. Mirrors and probes, once used, were disinfected with Cidex before being dried using gauze. Gauze was also used to dry the teeth and wipe away gross debris when necessary (after scoring the plaque). During the examination, laminated pictures as reference cards for the various indexes were within reach, meant for use when in doubt (Addendum 6.2).

#### 4.3.4 Referral

Children who required urgent treatment were referred to the Nepalese dental team, using an English referral sheet for easy and fluent communication between the examiners and treating dentists (Addendum 6.3.1). The treatment site was situated in a well-lit room with a chair and a bench to position the children in need of treatment. The Nepalese dental team involved in this project brought all equipment with them: anaesthesia, restorative materials, needed instruments for caries curettage and placement of a filling, extraction materials, sterilization products... The Nepalese dentists and dental assistants provided the best possible care with the available materials. When possible and if ethically acceptable, the carious lesions were filled using a hand mixed glass ionomer (Shofu), placed by using the thumb technique, an adapted version of the Atraumatic Restorative Treatment (ART) technique. Using glass ionomer restorative materials and hand instruments, ART is an interceptive technique that can be performed at low cost, without the need for expensive dental equipment, running water or electricity (23, 41). When it seemed necessary, extractions were recommended, e.g. root residues, carious lesions with pulpal involvement leading to visual abscesses, fistulas and ulcerations. When the extractions could not be performed because of the lack of appropriate treating materials, a referral to a higher level was made (Addendum 6.3.2).

#### 4.4 Questionnaires

Three questionnaires were used to collect information on oral health knowledge, attitude towards oral health, reported oral hygiene behaviour, dietary habits and OHRQoL. The used questionnaires contained multiple choice questions and were content validated and pre-test validated based on the Oral Health data Registration and Evaluation System (OHRES) study executed by Declerck et al. (2013) (56). The questionnaires were originally constructed in English, translated into the Nepalese language and back-translated. All three questionnaires were used at T0 and T1 to compare changes in the given answers over time.

In the first questionnaire (Addendum 7.1), general information was collected and the oral health knowledge of the schoolchildren was investigated. The second questionnaire (Addendum 7.2) examined the oral hygiene behaviour and dietary habits. Questions about tooth brushing methods and frequency as well as nutritional habits in the context of sugar consumption were included. The third questionnaire (Addendum 7.3) pointed out the oral health impact on the QoL from the children. As Knevel et al. (2008) (13) stated that OHRQoL is important to evaluate, questions were asked about the functional, social and emotional well-being, taking into account the oral health and appearance of the smile. Furthermore, previous oral health education and oral health resources were questioned.

Taking into account that the children can inform each other about the correct answers, the questionnaires were given and filled in as soon as possible after arrival. The first days in Kerung, all classes completed the questionnaires under the watchful eye of the teacher and with the help of the Nepalese dentists for additional explanation and translation. The absent children got the questionnaires when they visited school. The youngest children, who could not read and write yet, got the questionnaires to fill in at home with the help of their parents.

#### 4.5 Oral health promotion program

Suttagul et al. (2016) (21) reported that a dental camp including an oral health program can give an incentive to the subjects to change their perception, attitude and practice about oral health and that it can play a meaningful part in bringing awareness about the oral health and prevention of oral diseases. According to previously executed studies, it was emphasized that attention should be given to oral health promotion and prevention instead of giving priority to treatment, as dental treatment is mostly beyond the financial capacity of people living in emerging countries such as Nepal (3, 7, 8, 12, 13, 22, 38).

As proven in literature, primary schools provide an excellent environment for oral health promotion. It is an ideal setting to bring awareness to the children regarding their oral health, to teach them the importance of prevention and to change their knowledge, attitude and practice (5, 19, 21, 26, 43).

Every morning, about 50 children were screened. In the afternoon, the same children received an oral health educational program, which focused mainly on tooth brushing methods and frequency, as well as on dietary habits. The aim of the educational program was to increase empowerment by motivating the children and providing them with the needed skills and knowledge, as well as making them aware of the importance of oral self-care.

Because of the language barrier, the lesson was given in English with consecutive translation in Nepalese by one of the involved dentists. The youngest children (mostly accompanied by one of their parents) only received individual training following the dental examination, whereas most schoolchildren from the age of 6 years and older followed the complete oral health educational program.

A theoretical lesson was developed which elaborated on basic knowledge about dentition and how to take care of it. The lesson was supported by the use of self-designed posters (Addendum 8.1). The children learnt about the different kinds of teeth and the difference between the primary and permanent dentition, as well as the importance and influence of the primary dentition on its successors. Focus was put on brushing the teeth twice a day for at least two minutes using a fluoride containing toothpaste. The development of caries was explained, illustrated by clear pictures and cardboards (Addendum 8.2) showing a healthy and unhealthy situation of a tooth and the surrounding tissues. The impact of sugar consumption on oral health was clarified. During an interactive game using red and green cards that the children had to show, they learnt which nutritional products are healthy or unhealthy for the teeth. After the theoretical part, the children were taught how to brush properly in a practical and interactive lesson. A comprehensive brushing demonstration was given while explaining the correct brushing technique. Prior to letting the children brush their teeth with a provided toothbrush and toothpaste, they got a plaque disclosing tablet, giving them a realistic representation of their present brushing method. The visualized plaque was then brushed away, using the learnt technique.

An easy song was developed to summarize the main message. The song was learnt using a poster (Addendum 8.1) containing the Nepalese translation, helping the children to understand the take home message.

All posters used during the educational program were plasticized and given to be displayed at the school library. A summary poster was created to be hung up in every classroom, so the children were reminded daily about the given education and would not forget the importance of taking care of their teeth (Addendum 8.1).

Some games were developed to give the children the chance to learn about their oral health in an interactive way. Puzzles were made for the youngest children. They contained illustrations about the different kinds of teeth, the dentist and his instruments, tooth brushing, ... (Addendum 8.3). A game of memory was developed to play with the children. The cards

consisted of pictures related to oral health and oral health care (Addendum 8.4). For the older children, crossword puzzles and word search puzzles (Addendum 8.5) were developed.

At the end of the educational program the children got a toothbrush, a tube of fluoridated toothpaste, a card and stickers as a reminder to brush twice daily (Addendum 8.6), a brushing diploma (Addendum 8.7) and an informative folder (Addendum 8.8.1). The information brochure puts emphasis on the frequency of brushing, the use of fluoridated toothpaste and the negative impact of sugar consumption on the oral health. During the six-month period between T0 and T1 the children were provided with a new toothbrush and additional toothpaste after three months. This allowed the children to maintain a good oral health during the intermediate period.

As literature shows that school teachers, parents and media are the most important health information sources for schoolchildren (5, 19, 21, 22, 26, 43), it was decided to not only give the children an oral health program, but also provide information to the teachers. This was done through a custom-made teach-the-teacher leaflet and course so that the teachers would be able to reinforce the given information in the future. In this course, the subject matter given in the theoretical lessons of the oral health educational program was repeated for them. The teachers were given tips and tricks on how to best deliver and repeat the message from the oral health program. Apart from the posters, which are available in the school library, all the teachers received a booklet. In this booklet, all of the posters were specified with the accompanying explanation (Addendum 8.9).

## [4.6 Adaptations in methodology at T1](#)

### [4.6.1 Adaptations as a consequence of encountered issues](#)

After the first visit, a few adaptations were made in the methodology as a consequence of encountered issues.

#### [4.6.1.1 Clinical examination](#)

During the clinical examination at T0, a high rate of calculus was found. As a response, calculus was screened and materials for calculus removal (an ultrasonic scaler and periodontal hand instruments) were provided at T1.

#### [4.6.1.2 Oral health program](#)

Regarding the current level of English language, it became clear that the crossword and word search puzzles were too difficult. The puzzles were stored at the school library and focus was

put on the children understanding the main message. For the same reason, the informative folder for the parents, at first written in English, turned out to be difficult to understand. For the second visit, a new, more intelligible, Nepalese translated folder was developed (Addendum 8.8.2).

#### 4.6.2 Additions

As recommended in literature (13), different types of toothpaste were bought in Kathmandu and Kerung to explain the importance of fluoride in toothpaste. Worldwide known brands and local toothpaste brands were collected to visualise which tubes contained adequate fluoride levels and thus were appropriate to use (1).

The developed brushing song was added to the morning ceremony of the Kerung school. This ceremony takes place every morning before the children start their daily school activities. Consequently, the children are reminded every morning to brush twice a day with a fluoride containing toothpaste.

## 5. RESULTS

Data was initially collected in Excel. SPSS 24 was used to process the collected data.

### 5.1 Descriptive statistical analysis

#### 5.1.1 Descriptive statistical analysis T0

##### 5.1.1.1 General information

In total 359 children participated in the study, of whom 357 were screened and 354 filled in a questionnaire. The mean age of the examined children was 13.24 years (SD = 4.04), ranging from minimum 2 years old up to maximum 22 years old. When differentiated in two age groups ( $\leq 12$  years old and  $> 12$  years old), 39.6% of the children were 12 years old or younger and the majority of the children (60.4%) turned out to be older than 12 years (Table 5.1). Logically, the greater part (68.1%) of the examined children had a complete permanent dentition, 24.6% had a mixed dentition and only 7.3% of the children had a primary dentition. The male/female ratio was 1/1.70 with 133 (37.0%) males and 226 (63.0%) females.

Regarding the profession of the parents from the examined children according to the International Standard Classification of Occupations (ISCO) (57), the majority of the fathers could be classified in the groups skilled agricultural, forestry and fishery workers (farmer, fisher, wood cutter, shepherd, ...) and craft and related trade workers (carpenter, builder, tailor, stone breaker, ...). The majority of the mothers could be classified under the group skilled agricultural, forestry and fishery workers as well. 46.3% of the fathers and 85.0% of the mothers were farmers. The classification of the profession of the parents is visualised in figure 5.1.

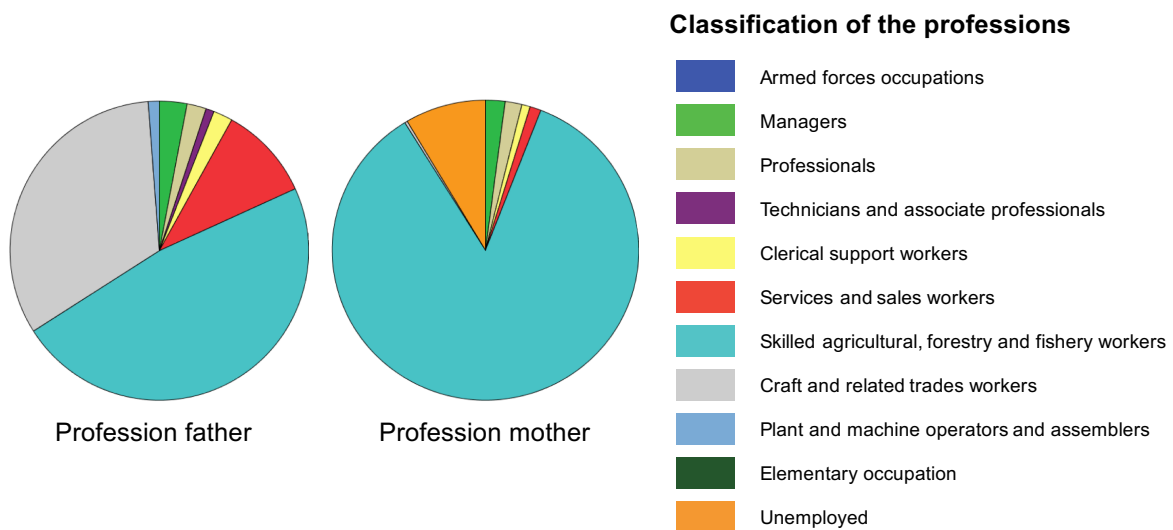


Figure 5.1 Classification of the profession of the parents according to ISCO (57): pie charts.

Table 5.1 Descriptive statistical analysis: general information of the sample at T0.

Age group	Number of children	Percentage
≤ 12 years old	n = 142	39.6%
> 12 years old	n = 217	60.4%
Total	n = 359	100.0%

### 5.1.1.2 Screening

The mean plaque score was 0.77 and 13.7% of the children were plaque free. It was observed that plaque was present on the upper molars in 75.5% of the children. Comparing the two previously defined age groups, a significant difference in mean plaque score was found, with the youngest age group presenting with more plaque than the oldest age group (mean difference = 0.40, 95% CI [0.27;0.53],  $p < 0.001$ ). A statistically significant difference was found among males and females, showing that boys presented on average with a higher mean plaque score than girls (mean difference = 0.27, 95% CI [0.13;0.41],  $p < 0.001$ ).

The mean DMFT/dmft was 9.16, ranging from 0 to 20. The DMFT/dmft was mainly dominated by the decayed component. Only 19 children (5.3%) presented with one or more fillings in their mouth and only 22 children (6.1%) presented with a missing tooth due to caries. Based on the  $D_3MFT/d_3mft$ , the prevalence of dental caries was 79.0%. Within the youngest age group, 84.6% presented with dental caries, while this was 75.5% in the oldest age group. This difference in  $D_3/d_3$  between the two age groups was found to be statistically significant (mean difference = 1.96, 95% CI [1.03;2.61],  $p < 0.001$ ). No statistically significant difference in caries status among males and females was found. Evaluating the  $D_1MFT/d_1mft$  and  $D_3MFT/d_3mft$  separately, it was observed that the mean score was respectively 4.65 and 3.48. The care index showed a mean percentage of 2.1% and the treatment index showed a mean percentage of 4.4%. Regarding the clinical consequences of untreated dental caries, 16.8% of the examined children showed a PUFA score of one or higher, with an upper limit of seven.

The majority of the examined children (80.4%) showed no signs of erosive tooth wear. The 70 children (19.6%) presenting with dental erosion had a mean BEWE score of 2.9. Furthermore, only 11.8% of the examined children presented with an untreated dental trauma, most of them occurring on the central incisors of the upper jaw.

Considering MIH, fluorosis and hypoplasia as enamel anomalies, 7.6% of the examined children presented with one of the aforementioned conditions. Five children (1.4%) had signs of MIH, with only one of them scoring severe degradation according to the EAPD guidelines



(53). 4.0% of the examined children presented with fluorosis and 3.1% showed one or more teeth with any form of hypoplasia.

Regarding developmental disorders, 3.1% of the children showed one of the following disorders: fusions (0.3%), geminations (0.6%), peg-shaped teeth (0.8%), dens invaginati (0.8%), hypoplasia (3.1%), hypodontia (0.3%), microdontia (0.6%) and mesiodens teeth (0.3%).

Regarding malocclusion, 2.8% of the children older than 12 years showed vertical malocclusion, while 3.2% of them presented with horizontal malocclusion.

### 5.1.1.3 Questionnaires

#### 5.1.1.3.1 Questionnaire 1: Knowledge

Evaluating the knowledge before giving the children the oral health program, the average score of the children who completed all five knowledge questions was 1.47. Not one child scored the maximum score of five out of five. The two questions with the most incorrect answers were '*How many times do you need to rinse your mouth after brushing?*' and '*What product in toothpaste is important for your teeth?*', respectively answered correct by 8.9% and 22.0% of the children.

#### 5.1.1.3.2 Questionnaire 2: Oral health habits

##### 5.1.1.3.2.1 Brushing behaviour and attitude towards oral health

Aside from the objective evaluation seen in the plaque score, the questionnaires offered a subjective point of view on the brushing behaviour of the children. In this respect, 76.4% of the children who filled in the questionnaires reported to brush at least twice a day and 2.1% of the children reported to never brush their teeth. Brushing for at least two minutes was done by 81.9% of the children. The majority of the children had a good attitude towards their oral health. 84.2% of the children found it important to care for their teeth and 90.0% thought that a healthy mouth is important for their general health. On the other hand, 45.7% of the children reported to be afraid of the dentist.

##### 5.1.1.3.2.2 Nutritional habits

Eating sugar-containing snacks in between meals more than once a day was reported by 13.7% of the children, while 20.5% of the children claimed to never eat fruit. On the other hand, 16.2% of the children stated to eat at least one piece of fruit a day. The use of chewing gum at least once a day was reported by 30.0% of the children, while 7.9% of the children reported

to never use chewing gum. Having sugar-containing food after they brushed their teeth in the evening was reported by 9.5% of the children.

Respectively 45.7% and 33.2% of the children reported to drink soft drinks or fruit juices at least once a day. Drinking soft drinks or fruit juices before brushing their teeth in the evening was a habit for 33.1% of the children, while 13.9% of the children declared to drink these sugar-containing drinks after brushing their teeth in the evening.

#### 5.1.1.3.3 Questionnaire 3: Oral health-related quality of life

More than half of the questioned group (61.4%) has had a toothache or experienced oral pain in their life before, of which 4.4% reported to have experienced this often or even daily. 49.5% of the children reported to have complaints during eating and drinking.

Respectively 37.0%, 30.1% and 43.8% of the examined children reported to be or have been sad, irritated or shy about their oral health situation at least once in their life. In this respect, 43.6% of the children reported to have never been worried about other people's opinion about their mouth, while 9.3% acknowledged to be worried often or (almost) every day about other people's opinion about their teeth and mouth. The majority of the children has never had any complaint about halitosis, whilst 9.4% had this complaint often or even daily (Table 5.2).

*Table 5.2 Descriptive statistical analysis: OHRQoL at T0.*

<b>Complaint because of their oral health situation</b>	<b>Never</b>	<b>One or two times</b>	<b>Some-times</b>	<b>Often</b>	<b>(Almost) every day</b>
Toothache/oral pain	38.6%	5.9%	51.2%	2.5%	1.9%
Bad breath	53.3%	4.7%	32.5%	6.9%	2.5%
Problems during sleeping	77.6%	6.1%	14.7%	1.3%	0.3%
Problems during eating and drinking	50.5%	5.4%	36.9%	5.0%	2.2%
Feeling sad	63.0%	3.8%	30.1%	1.6%	1.6%
Feeling irritated	69.9%	7.3%	18.9%	4.0%	0.0%
Feeling shy	56.2%	3.9%	34.7%	5.2%	0.0%
Worried about other people's opinion	56.4%	4.5%	29.8%	7.1%	2.2%
Being bullied	81.1%	3.2%	13.2%	0.6%	1.9%
Avoided smiling with teeth visible	64.6%	3.1%	22.5%	9.1%	0.9%
Missed school	44.7%	6.3%	45.6%	2.5%	0.9%

## 5.1.2 Descriptive statistical analysis T1

### 5.1.2.1 General information

A total of 339 children participated in the second part of the study in November 2018 (T1), of which 266 (78.5%) were also seen at T0. 328 of the 339 children were screened and 327 children completed the questionnaires. The mean age of the children was 13.14 years (SD = 3.79). The minimum age was 2 years old and the maximum age was 24 years old. 37.2% of the children were 12 years old or younger and the majority of the children (62.8%) were 13 years or older (Table 5.3). The male/female ratio was 1/1.78, with 122 (36.0%) of the children being male and 217 (64.0%) of the children being female. It was observed that 64.6% of the children had their complete permanent dentition, 28.4% had a mixed dentition and 7.0% had a primary dentition.

Table 5.3 Descriptive statistical analysis: general information of the sample at T1.

Age group	Number of children	Percentage
≤ 12 years old	n = 126	37.2%
> 12 years old	n = 213	62.8%
Total	n = 339	100.0%

### 5.1.2.2 Screening

At T1, the mean plaque score was 0.48 and 24.2% of the children were free of plaque. It was observed that the majority of the children (64.9%) presented with plaque on the upper molars. A significant difference was found between the two previously defined age groups, where the youngest age group had a higher mean plaque score than the older age group ( $p < 0.001$ ). Moreover, a statistically significant difference was found in the mean plaque score based on gender. On average, boys showed a higher mean plaque score than girls (mean difference = 0.13, 95% CI [0.02;0.24],  $p < 0.05$ ). Calculus was found in 38.7% of the examined children.

The mean DMFT/dmft was 8.03, with a minimum DMFT/dmft of 0 and a maximum DMFT/dmft of 19. In 91.4% of the children, no teeth were missing due to caries. One or more dental fillings were found in 33.9% of the screened children. The mean score for D<sub>1</sub>MFT/d<sub>1</sub>mft, respectively D<sub>3</sub>MFT/d<sub>3</sub>mft were 4.40 and 3.16. The prevalence of dental caries, seen in the D<sub>3</sub>MFT/d<sub>3</sub>mft score, was 63.7%, with no statistical significant difference found for gender. A statistically significant difference was found based on age, with the children of the youngest age group showing more dental caries than the children of the oldest age group (mean difference = 1.63, 95% CI [1.10;2.17],  $p < 0.001$ ). The care index had a mean score of 27.6% and the treatment index had a mean score of 31.7%. Of the examined children, 45.3% reported to have never

received treatment. 19.5% of the children showed a PUFA score of one or higher, ranging up until six.

### 5.1.2.3 Questionnaires

#### 5.1.2.3.1 Questionnaire 1: Knowledge

Analysing the five questions regarding the oral health knowledge, the children obtained a mean score of 1.81 out of five. The questions with the most correct responses were about tooth friendly products and about the erosive effect of Coca Cola on teeth. Accurate answers on fluoride being the most important ingredient in toothpaste were given by 23.7% of the children.

Almost all children (96.5%) stated to have received oral health education, of which 69.2% received the information once, in the oral health program of the project six months earlier. 20.9% had received oral health information more than once. When analysing the oral health information sources, excluding the present oral health program, 67.1% of the children had received oral health information in school. Respectively 4.7% and 8.8% received oral health information through their parents or the media.

#### 5.1.2.3.2 Questionnaire 2: Oral health habits

##### 5.1.2.3.2.1 Brushing behaviour and attitude towards oral health

Brushing at least twice a day was a habit for 85.7% of the children and 91.5% stated to do this for two minutes or more. When asked about the tools used to brush their teeth, the majority of the children (87.3%) indicated they used their own toothbrush to brush their teeth. A family toothbrush was used by 2.8%. Respectively 0.9%, 0.9% and 3.4% used their finger, a wooden stick or datiwani (a stick with antiseptic properties). Apart from the previously mentioned materials, 42.5% of the children stated to use toothpaste.

A positive attitude was recorded concerning oral health. Taking care of their teeth was important for 91.4% of the children and 91.6% agreed with the statement that a healthy mouth is important for their general health. Being afraid of the dentist was a problem experienced by 27.6% of the children.

##### 5.1.2.3.2.2 Nutritional habits

Eating sugar-containing snacks in between meals more than once a day was reported by 3.9% of the children. 12.0% of the children stated they eat a piece of fruit once a day, while 10.4% declared to never eat any fruits. It was stated by 32.1% of the subjects that they chewed gum at least once a day and 13.1% of them reported to never use chewing gum. Almost all

questioned children (97.4%) said they do not eat sweets after they brush their teeth in the evening.

When asked about their drinking habits, 36.7% and 28.0% of the children reported to drink soft drinks, respectively fruit juices at least once a day. Drinking soft drinks or fruit juices before brushing their teeth in the evening was a habit for 19.4% of the children, while 4.4% of the children declared to drink these sugar-containing drinks after brushing their teeth in the evening. Drinking sugary tea once a day or more was done by 41.7% of the children.

#### 5.1.2.3.3 Questionnaire 3: Oral health-related quality of life

It was stated by 56.3% of the children that they had experienced toothache or oral pain in their life before. Experiencing tooth pain often was reported by 1.0% of the children. Problems with cold and heat during drinking were found in 52.4% of the children, with 5.6% indicating they had these problems often or even every day.

When asked about their feelings about their oral situation, respectively 21.3%, 16.7% and 27.8% reported to be or have been sad, irritated or shy about their oral health situation at least once in their life. 67.5% of the children answered to have never been worried about others people's opinion about their teeth. Missing school as a result of their oral health situation has been a problem for 23.5% of the children. Because of their oral health situation, 14.3% of the children have been bullied before. A bad breath was never experienced by 60.0% of the children. (Table 5.4).

*Table 5.4 Descriptive statistical analysis: OHRQoL at T1.*

<b>Complaint because of their oral health situation</b>	<b>Never</b>	<b>One or two times</b>	<b>Some-times</b>	<b>Often</b>	<b>(Almost) every day</b>
Toothache/oral pain	43.7%	3.5%	51.4%	1.0%	0.3%
Bad breath	60.0%	2.9%	32.6%	3.9%	0.6%
Problems during sleeping	82.0%	0.9%	15.5%	1.6%	0.0%
Problems during eating and drinking	52.4%	4.1%	37.9%	4.7%	0.9%
Feeling sad	78.7%	0.9%	17.9%	1.9%	0.6%
Feeling irritated	83.3%	1.9%	14.2%	0.6%	0.0%
Feeling shy	72.2%	2.8%	23.1%	1.3%	0.6%
Worried about other people's opinion	67.5%	1.9%	28.7%	1.9%	0.0%
Being bullied	85.7%	0.6%	13.4%	0.3%	0.0%
Avoided smiling with teeth visible	79.0%	1.6%	17.1%	2.2%	0.0%
Missed school	76.5%	2.9%	19.9%	0.6%	0.0%

## 5.2 Prospective statistical analysis

In order to compare the oral health knowledge, oral health habits and the prevalence of decay, plaque and other oral health problems between the two measurements points, paired tests were performed. Measurements that could be considered scale variables (Likert scales with five or more answer possibilities) were compared using paired T-tests. Measurements that could be considered ordinal (Likert scales with less than five answer possibilities) were compared using the Wilcoxon signed rank test. Finally, binary measurements were compared with a McNemar test. All tests were performed at 95% confidence levels.

In order to test the effects of age and gender on the efficacy of the oral health program, random intercept models were executed with the mean plaque score, D/d, D<sub>3</sub>/d<sub>3</sub> and PUFA as within variable respectively, and age and gender as between-subject variables. Subject identification number was treated as a random intercept.

### 5.2.1 General information about the paired sample

A total of 266 children, who were screened at T0 as well as T1, were included in the paired prospective part of the study. The mean age of the children was 12.88 years old at T0 (SD = 3.63). The age values ranged between 2 and 20 years old. 39.8% of the children were 12 years old or younger, 60.2% of the children were 13 years old or older (Table 5.5). The male/female ratio was 1/1.66, with 100 (37.6%) male children and 166 (62.4%) female children. The sample was checked for normality.

*Table 5.5 Prospective statistical analysis: general information about the paired sample.*

Age group	Number of children	Percentage
< 12 years old	n = 106	39.8%
> 12 years old	n = 160	60.2%
Total	n = 266	100.0%

### 5.2.2 Paired T-tests

The results from the paired T-tests are given in table 5.6.

#### 5.2.2.1 Screening

After the oral health program the amount of plaque (mean difference T1-T0 = -0.28, 95% CI [-0.35;-0.21], p < 0.001), D/d (mean difference T1-T0 = -1.76, 95% CI [-2.21;-1.32], p < 0.001) and D<sub>3</sub>/d<sub>3</sub> (mean difference T1-T0 = -1.32, 95% CI [-1.60;-1.04], p < 0.001) showed a significant decrease. There was no statistically significant difference found in PUFA between T0 and T1.

### 5.2.2.2 Questionnaires

The total knowledge score (mean difference T1-T0 = 0.27, 95% CI [0.05;0.49],  $p < 0.05$ ) significantly increased between T0 and T1.

The frequency of drinking soft drinks (mean difference T1-T0 = -0.26, 95% CI [-0.47;-0.04],  $p < 0.05$ ) significantly decreased after the oral health program. In contrast, the frequency of eating citrus fruits (mean difference T1-T0 = 0.25, 95% CI [0.01;0.49],  $p < 0.05$ ) increased. There was no statistically significant difference found in the frequency of drinking fruit juices and the frequency of brushing the teeth between T0 and T1.

Table 5.6 Prospective statistical analysis: paired samples T-test.

Paired samples T-test					
Pair (T1 – T0)	Paired difference		T	Df	p-value
	Mean difference	95% CI of the difference			
Plaque mean	-0.28	[-0.35;-0.21]	7.843	265	< 0.001
D/d	-1.76	[-2.21;-1.32]	7.813	265	< 0.001
D <sub>3</sub> /d <sub>3</sub>	-1.32	[-1.60;-1.04]	9.317	265	< 0.001
PUFA/pufa	-0.04	[-0.14;0.06]	0.836	262	0.404
Knowledge total score	0.27	[0.05;0.49]	-2.396	179	0.018
Frequency of brushing the teeth	0.11	[-0.04;0.26]	-1.448	219	0.149
Frequency of drinking soft drinks	-0.26	[-0.47;-0.04]	2.308	234	0.022
Frequency of drinking fruit juices	-0.08	[-0.25;0.10]	0.852	236	0.395
Frequency of eating citrus fruits	0.25	[0.01;0.49]	-2.065	221	0.040

### 5.2.3 Wilcoxon signed rank tests

In the data collected from the questionnaires, there was no statistically significant difference found in the frequency of eating sugar-containing snacks and the feeling about the oral health situation between T0 and T1 (Table 5.7).

Table 5.7 Prospective statistical analysis: related-samples Wilcoxon signed rank test.

Related-samples Wilcoxon signed rank test	
Pair (T0 vs T1)	p-value
Frequency of eating sugar-containing snacks	0.146
Feeling shy, sad and/or irritated about their oral health situation	0.159

### 5.2.4 McNemar tests

The binary comparisons showed significant improvements in knowledge regarding question two ‘Which of the following product is tooth friendly?’ and question five about different tooth types ( $p < 0.05$ ). While 141 respondents (55.5%) answered question two wrongly at T0, this

number was reduced to 111 respondents (44.6%) at T1. At T0, 41 children (17.1%) answered question five about the four different tooth types correctly, while at T1 this number increased up to 79 children (32.6%). Question one, three and four showed no significant difference in correct answers between T0 and T1 (Table 5.8).

After the oral health program, a significantly higher amount of children spent at least two minutes brushing their teeth ( $p < 0.05$ ) (Table 5.8).

Table 5.8 Prospective statistical analysis: related-samples McNemar test.

Related-samples McNemar test						
Pair (T0 vs T1)	p-value	Answer possibilities	Frequencies (%)			
			T0		T1	
			n	%	n	%
Time used to brush their teeth	0.046	< 2 minutes	43	16.9	19	7.8
		≥ 2 minutes	211	83.1	225	92.2
Question 1: What product in toothpaste is important for your teeth?	0.585	Wrong	187	77.3	192	76.2
		Correct	55	22.7	60	23.8
Question 2: Which of the following products is toothfriendly?	0.032	Wrong	141	55.5	111	44.6
		Correct	113	44.5	138	55.4
Question 3: How many times do you need to rinse your mouth after brushing?	1.000	Wrong	231	89.9	229	89.8
		Correct	26	10.1	26	10.2
Question 4: Does coca cola light give tooth erosion?	0.368	Wrong	113	45.2	103	40.6
		Correct	137	54.8	151	59.4
Question 5: Different tooth types.	0.002	At least one wrong answer	199	82.9	163	67.4
		Four correct answers	41	17.1	79	32.6

## 5.2.5 Random intercept models

### 5.2.5.1 Mean plaque score

The random intercept model with the mean plaque as the within-subjects variable showed a significant decrease in mean plaque over time (mean difference = 0.31, 95% CI [0.25;0.38],  $p < 0.01$ ), a significant effect of gender (mean difference = 0.16, 95% CI [0.08;0.24],  $p < 0.001$ ) where boys had on average more plaque, and a negative effect of age ( $B = -0.03$ , 95% CI [-0.04;-0.01],  $p < 0.001$ ). Furthermore, there was a significant interaction effect between time and gender ( $p < 0.05$ ), showing that on average boys profited more from the program than girls (Figure 5.2). There was no statistically significant interaction effect found between time and



age. A Kolmogorov-Smirnov test on the residuals showed non-normality (KS = 0.30,  $p < 0.001$ ), meaning that the results should be treated with caution.

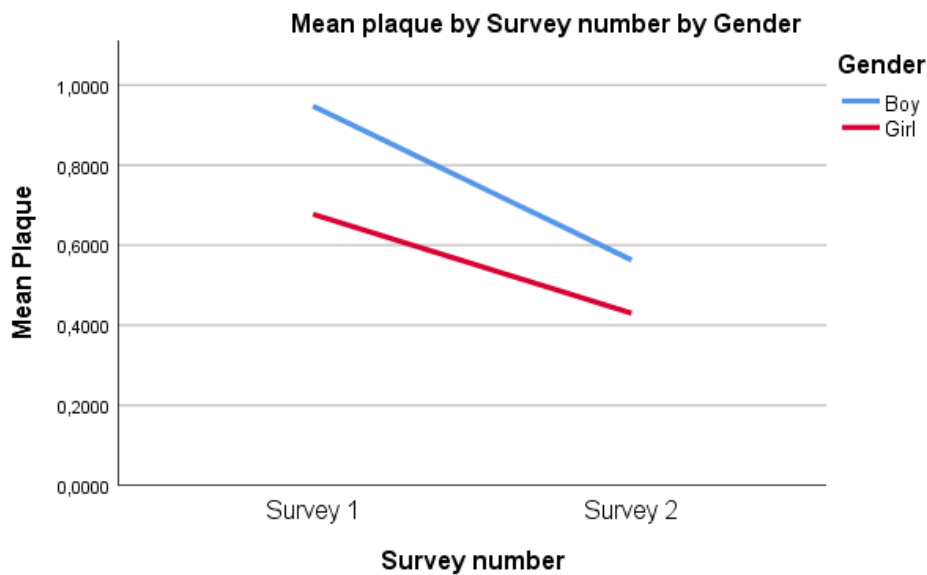


Figure 5.2 Prospective statistical analysis: random intercept model plaque: the interaction effect between time and gender.

#### [5.2.5.2 D/d](#)

The random intercept model with D/d as the within-subjects variable showed only a significant decrease in D/d with time (mean difference = 2.09, 95% CI [1.65;2.53],  $p < 0.05$ ). No statistically significant effect was found of age or gender, as well as no interaction effect was found between time and age or between time and gender. A Kolmogorov-Smirnov test showed that the residuals are normally distributed (KS = 0.03,  $p = 0.20$ ).

#### [5.2.5.3 D<sub>3</sub>/d<sub>3</sub>](#)

The random intercept model with D<sub>3</sub>/d<sub>3</sub> as the within-subjects variable showed a significant decrease in D<sub>3</sub>/d<sub>3</sub> with time (mean difference = 1.29, 95% CI [1.01;1.58],  $p < 0.001$ ) and a significant negative effect of age (B = -0.18, 95% CI [-0.25;-0.11],  $p < 0.001$ ). No statistically significant effect of gender was found. There was no significant interaction effect found between time and age or between time and gender. A Kolmogorov-Smirnov test on the residuals showed non-normality (KS = 0.10,  $p < 0.001$ ), meaning that the results should be treated with caution.

#### [5.2.5.4 PUFA](#)

The random intercept model with PUFA as the within-subjects variable showed only a significant negative effect of age ( $B = -0.04$ , 95% CI  $[-0.07; -0.02]$ ,  $p < 0.001$ ). No statistically significant effect of time or gender was found. There were no significant interaction effects between time and age or between time and gender. A Kolmogorov-Smirnov test on the residuals showed non-normality ( $KS = 0.30$ ,  $p < 0.001$ ), meaning that the results should be treated with caution.

## 6. DISCUSSION

### 6.1 Interpretation of the results

#### 6.1.1 Screening

##### 6.1.1.1 Plaque

In the present study, 13.7% of the children were plaque free and the mean plaque score at T0 was 0.77, which is comparable with the data from Westbacke (2006) (38), where a mean plaque score between 0.5 and 0.8 was recorded in children aged between 5 and 16 years old. In the previously mentioned study (38), only 2.4% of the children were free of plaque. In accordance with the study performed by Westbacke (2006) (38), boys had statistically significant more plaque than girls and the plaque amount decreased with age at T0. In the present study at T1, a higher percentage of plaque free children (24.2%) and a significantly lower mean plaque score of 0.48 was noted, which could be ascribed to the oral health program.

##### 6.1.1.2 Calculus

In the present study, 38.7% of the examined children had calculus and subsequently received a calculus removal treatment, performed by the Nepalese dental team. Although a substantial amount of calculus was present, the findings were still lower than those of Helderma et al. (1998) (6), who showed that 68.0 to 97.0% of the 12 to 19-year-olds had calculus. Knevel et al. (2008) (13) and Westbacke (2006) (38) reported respectively that 50.0% of children aged between 5 and 12 years old and 63.0% of children aged between 5 and 16 years old presented with calculus.

##### 6.1.1.3 DMFT

Studies reporting on the caries prevalence and DMFT/dmft in Nepalese children showed considerable differences in study design. For this reason, it was not evident to compare the present results with the existing literature.

In the present study, DMFT/dmft recorded at T0 was 9.16. Fukai et al. (2012) (5) reported DMFT scores between 0.32 and 0.80 for three age groups ranging between 6 and 16 years old. A DMFT of 1.2, 1.78 and 2.3 in children ranging from the age of 6 to 16 years old was reported in different studies respectively conducted by Khanal et al. (2014) (8), Shakya et al. (2014) (19) and Thapa et al. (2015) (22). Comparable with the present study, most studies found that the decayed component made up the biggest portion of the DMFT (3, 5, 6, 8, 10, 12, 19).

Dental caries prevalence in this study was 79.0% at T0 and regarding the defined age groups, there was a statistically significant difference showing that the oldest age group presented with less decay than the youngest age group. This decrease in dental caries in older aged children can be a result of the exfoliation of primary decayed teeth. In the study conducted by Subedi et al. (2011) (42) a similar statistically significant finding was reported, showing a caries prevalence of 69.0% in children of 5 to 6 years and 53.2% in children of 12 to 13 years. The Nepal National Oral Pathfinder Survey of 2004 (26) recorded that 57.5% of the 5 to 6-year-olds and 25.6% of the 12 to 16-year-olds suffer from dental caries. A study conducted by Prasai Dixit et al. (2013) (10) showed a caries prevalence of 52.0% in 5 to 6-year-olds and 41.0% in 12 to 13-year-old children. Khanal et al. (2014) (8) reported a caries prevalence of 58.3% in a group of 12 to 15-year-old children. In another study by Khanal et al. (2017) (12), a group of 468 primary schoolchildren showed a caries prevalence of 39.3% in the 5 to 10-year-olds and 60.7% in the 10 to 15-year-olds. In a study by Shrestha et al. (2014) (20), a prevalence of 42.6% was found in 12 to 15-year-old children. The caries prevalence in young aged children appeared to be high as well according to Limbu et al. (2017) (15) with a prevalence of 55.6% for 3 to 6-year-olds. In the present study, the DMFT/dmft score and caries prevalence were obviously higher than recorded in literature. This can be attributed to the fact that initial carious lesions, described as the second digit of the ICDAS score being 0, 1, 2 or 3, are included in the D/d in the present study, while other studies only considered progressive dental caries (second digit of the ICDAS score being 4, 5 or 6) as D/d. The vast intake of sugary food, inadequate oral health behaviour and the lack of oral health care services in Kerung are potentially explanatory factors as well.

In the present study, the care index had a mean percentage of 2.1% and the treatment index had a mean percentage of 4.4% at T0. In a study conducted by Limbu et al. (2017) (15) a restorative index of 2.9% was found in 3 to 6-year-olds. In multiple studies, a high need for treatment was observed (5, 8, 10, 19, 20, 22, 23, 42). At T1, a mean care index of 27.6% and a mean treatment index of 31.7% were present. The increase in treatment and restorative index is a result of the treatments performed at T0. At T1, a perfect score for the restorative and treatment index was not expected, because difficult extractions could not be executed and not all decay could be removed, as infrastructure did not allow non-cavitated carious lesions to be treated.

#### [6.1.1.4 PUFA](#)

In the present study at T0, 16.8% of the children had a PUFA score ranging from one to seven and at T1, 19.5% had a PUFA score ranging from one to six. This slight increase over time

can be attributed to the fact that a large amount of pathology could not be treated at T0 as a result of the lack of appropriate treating materials. In this respect, a lot of treatments were referred to a higher level. As previously mentioned, there is no availability of oral health care in Kerung and a high price comes along with the travel to a nearby hospital, discouraging the Kerung inhabitants from seeking oral health care. As a result, it was not expected that many of the referred patients attended another oral health authority (Addendum 2.1).

#### [6.1.1.5 MIH](#)

Five of the examined children in the present study (1.4%) showed signs of MIH. According to a meta-analysis conducted by Schwendicke et al. (2018) (58) the global prevalence of MIH is 13.1%. This is comparable to the findings of Shrestha et al. (2014) (59), who reported MIH in 13.7% of schoolchildren aged 7 to 12 years old in Kavre, a Nepalese village. A probable explanation for the low MIH score in this study can be attributed to a possible underestimation, because of the high amount of severely decayed first molars, of which it was not possible to evaluate whether or not they were affected by MIH. There is no consensus yet on the cause of MIH. A probable cause of MIH is said to be fever or ear infection at a young age, but there are no data from Kerung to corroborate this hypothesis.

#### [6.1.1.6 Fluorosis](#)

Milsom et al. (1997) (16) reported that 9.0% of the 360 12-year-old children had diffuse opacities. A more recent study performed by Thapa et al. (2015) (22) reported similar values, with 10.9% of the 12 to 13-year-olds having enamel fluorosis. In the present study, only 4.0% of the examined children presented with fluorosis. This low number is to be expected in a desolate mountain village with no artificially fluoridated water, access to fluoridated water or fluoride supplements. Most regions in Nepal are deprived of fluoride in groundwater (1, 6, 16, 18, 23) and fluoridated toothpaste was only introduced in the past fifteen years in Nepal (9).

#### [6.1.1.7 Untreated dental trauma](#)

Thapa et al. (2015) (22) addressed that 4.5% of the investigated children aged 12 to 13 had experienced dental trauma. In the current study, 11.8% of the children presented with untreated dental trauma, mostly on the central incisors of the upper jaw.

#### [6.1.1.8 Erosion, malocclusion and developmental disorders](#)

There was no possibility to compare the outcomes found for malocclusion or developmental disorders, as no validated scoring system was used. Moreover, erosion, malocclusion and

developmental disorders were topics not previously investigated or described in other studies executed in Nepal.

## 6.1.2 Questionnaires

### 6.1.2.1 Questionnaire 1: Knowledge

When asked about the importance of fluoride at T0, 22.0% of the children answered adequately. This correlates with other studies where knowledge about fluoride and its benefits on oral health appeared to be low (10, 13, 19, 26). In the study of Buunk-Werkhoven et al. (2011) (4), the overall oral health knowledge in Nepal appeared to be low, which is in accordance with the overall score on the knowledge section in this study (1.47/5). In the present study, a significant improvement in knowledge was found at T1, which could be assigned to the oral health promotion program. However, the mean score at T1 was still low (1.81/5). The reason for this moderate improvement in oral health knowledge can most probably be attributed to the language barrier, a lack of emphasis on certain subjects during the educational program and the level of the program, which could be considered too high for certain children.

### 6.1.2.2 Questionnaire 2: Oral health and nutritional habits

At T0, 76.4% of the children reported to brush their teeth twice a day, which is remarkably higher than the 16.9% to 36.9% found in literature (4, 5, 8, 10, 13, 22, 25, 38). In the present study, 81.9% of the subjects reported to brush for two minutes or more, while in the study by Humagain (2011) (25) only 32.0% of the questioned 13 to 18-year-olds reported to brush for two to three minutes. When clinically examining the oral cleanliness, it was not as good as could be expected from the questionnaires. The high percentage of favourable answers can presumably be attributed to response bias, where the children gave the socially acceptable answer, instead of their real brushing time and frequency. At T1, 85.7% of the children said to brush twice a day and 91.5% said to brush for two minutes or longer. This increase can possibly be attributed to the the oral health program. The majority of the children reported to use their own toothbrush to brush their teeth and smaller percentages stated they use a family toothbrush, their finger, a wooden stick or datiwani, which is similar to findings in literature (5, 8, 10, 13, 25, 38). 42.5% reported to use toothpaste during brushing, which is lower than the values varying between 65.0% and 86.1% in literature (1, 8-10, 19, 22, 26, 38). This could possibly be a consequence of the fact that not every child marked all the appropriate answers on the question about which products they use to brush their teeth, although the question clearly stated that more than one answer could be ticked.

At T0, 58.8% of the children reported to eat sugar-containing snacks between their meals more than once a day, which corresponded with the findings of Khanal et al. (2014) (8) where 51.6% of the 12 to 15-year-olds reported to consume sugary snacks more than three times a day. The Nepal National Oral Health Pathfinder Survey of 2004 (26) reported daily sugar consumption to be in between 74.0% to 77.8% for children aged 12 to 16 years old. Other studies showed a low frequency of sugar exposure (5, 10). In the present study, one third of the children (30.0%) indicated to chew gum daily. The high sugar intake in this study can be attributed to snacks and gum being abundantly provided in the local shops surrounding the centre of Kerung. In the present study, a substantial decrease to 23.3% in sugary snack consumption was noted at T1, which can most probably be attributed to the oral health educational program where the negative effects of sugar were taught.

In literature, a range of 73.8% to 87.0% of children drinking sugary tea at least once a day was found. This was presented as the most common reason for sugar intake (5, 13, 22, 26). In the present study, a lower percentage of 41.7% was recorded. Respectively 45.7% and 33.2% of the children reported to drink soft drinks or fruit juices at least once a day, which is clearly higher than in the study of Thapa et al. (2015) (22), where 42.9% of the 12 to 13-year-old children reported to drink soft drinks once a week. Although Kerung can be considered a remote village, large amounts of sugary food and drinks are available in the village.

#### 6.1.2.3 Questionnaire 3: Oral health-related quality of life

At T0, 61.4% of the children had experienced toothache or oral pain in their life before. This is almost double of the 31.0% of 8 to 16-year-old children and 32.0% of 12 to 13-year-old children who have suffered from oral pain in the studies respectively conducted by Prasai Dixit et al. (2013) (10) and Thapa et al. (2015) (22). The high number of children suffering from toothache can be attributed to the lack of dental care in Kerung and the high intake of cariogenic food and drinks. It is also common in Nepal to uphold a tolerance for pain and to live with it (19). At T1, 56.3% of the children declared to have experienced toothache or oral pain in their life before. The decrease in this percentage over time could possibly be explained by recall bias. Another explanation could be that the new children at T1 did not experience toothache or oral pain before.

Thapa et al. (2015) (22) and Yee et al. (2006) (1) showed that oral pain has a negative influence on school attendance. At T1 in the present study, 23.5% of the investigated children reported to have missed school because of their oral health, which is lower than found in the study by Shakya et al. (2014) (19).

In this study, 18.9% of the questioned children have been bullied and 35.6% have avoided smiling because of their oral health. These values are slightly higher than in the study conducted by Knevel et al. (2008) (13), where 11.0% of the 5 to 12-year-old children were made fun of because of their oral appearance and 26.0% avoided smiling because of their oral health. In the present study, 43.8% of the children stated to be or have been shy about their oral health situation at T0. This is lower in comparison to the study of Shakya et al. (2014) (10), but higher than in studies conducted by Knevel et al. (2008) (13) and Fukai et al. (2012) (5). Respectively 37.0% and 30.1% of the children at T0 reported to be or have been sad or irritated about their oral health situation at least once in their life. At T1, respectively 21.3%, 16.7% and 27.8% stated to be or have been sad, irritated or shy about their oral health situation at least once in their life. The decrease in these percentages over time can be explained again by recall bias and the new children at T1 not experiencing any of these feelings before.

At T0 in the present study, 22.4% and 49.5% of the examined children had respectively experienced sleeping or eating problems because of their oral health. Two studies (1, 13) reported sleeping and eating problems being the most frequent impact factors on the OHRQoL of children.

## 6.2 SWOT analysis

To review the project in a structured manner, a SWOT analysis was performed. The four categories of the SWOT analysis are briefly presented in Table 6.1.

### 6.2.1 Strengths

#### 6.2.1.1 Methodology

This project was built on a strong scientific foundation. A well-known study design in epidemiology was used. In contrast to most existing literature, the present study consisted of a prospective case series, with a six-month follow-up. A comprehensive screening was done to gather maximal data. Before the clinical examination all investigators were calibrated, in order to screen as uniformly as possible. The screening of the children was approached in a systematic manner, using a screening format (Addendum 6.1). The used questionnaires (Addendum 7) were content and pre-test validated. They were translated into the Nepalese language and back-translated. Whenever possible, potential obstacles were anticipated e.g. the race against time to fill in the questionnaires as soon as possible to reduce the probability of plagiarism of befriended children.



Table 6.1 SWOT analysis.

	FAVOURABLE	UNFAVOURABLE
INTERNAL	<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Methodology               <ul style="list-style-type: none"> <li>· Prospective study design</li> <li>· Comprehensive screening</li> <li>· Uniform and systematic screening</li> <li>· Questionnaires: content and pre-test validity, back-translation</li> <li>· Anticipation on possible encountered obstacles</li> </ul> </li> <li>• Charity project profiting Kerung inhabitants               <ul style="list-style-type: none"> <li>· Opportunity for oral health care</li> <li>· Raising awareness and self-efficacy about oral health</li> <li>· Creating supportive environment for maintaining oral health</li> </ul> </li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Methodology               <ul style="list-style-type: none"> <li>· Lack of control group</li> <li>· Convenience sample</li> <li>· Intermediate period between T0 and T1</li> <li>· Hawthorne effect</li> <li>· No screening calculus at T0</li> </ul> </li> <li>• Quality of treatment restricted by infrastructure</li> </ul>
EXTERNAL	<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Sponsoring               <ul style="list-style-type: none"> <li>· Septodont (France)</li> <li>· Department Paediatric Dentistry University Hospital Ghent (Belgium)</li> <li>· DentalPharma (Belgium)</li> <li>· Colgate (Belgium)</li> <li>· Soroptimist International (Belgium)</li> </ul> </li> <li>• Collaboration and communication</li> <li>• Kerung               <ul style="list-style-type: none"> <li>· Receptive and grateful attitude</li> <li>· Cooperation of the school</li> </ul> </li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Nepalese authorities</li> <li>• Kerung               <ul style="list-style-type: none"> <li>· Perspective of the inhabitants</li> <li>· Language barrier with the children</li> <li>· Accessibility</li> <li>· Sugar exposure</li> </ul> </li> </ul>

#### 6.2.1.2 Charity project profiting Kerung inhabitants

The project aimed to raise awareness and self-efficacy about oral health among the local inhabitants of Kerung. The oral health care offered in the project was a unique opportunity for them. The intention of the project was very much appreciated. A long-term mind-set was established, in an attempt to create a supportive environment to maintain an adequate oral health situation. In this respect, not only the children were given theoretical and practical lessons, also materials for oral health care education were offered to the children and school. The teachers were taught how to maintain the knowledge of the children through the teach-the-teacher approach and the parents were also involved by giving them an informational leaflet about oral health.

## [6.2.2 Weaknesses](#)

### [6.2.2.1 Methodology](#)

Although the methodology of the study showed many strengths, a few weaknesses were encountered. As establishing a control group was not possible, there was no scientific proof that the differences found at T1 could be ascribed to an effect of the oral health program. Moreover, the sampling method could be considered a weakness as well, as within this community only a convenience sample could be used. As a consequence, the found data should be interpreted with caution taking into account that no conclusions can be projected on the entire Nepalese population. Besides, it should be kept in mind that in the six months between T0 and T1 the oral health behaviour of the children was supported by providing them with a toothbrush and toothpaste, which most probably has had its influence on the brushing habits of the children. While interpreting the data, the Hawthorne effect should be taken into account. At T0, it became obvious that a substantial amount of calculus was present in the children. However, at that point there was a lack of instruments to remove calculus. Consequently, at T1 the presence of calculus was noted for the purpose of referral and materials for calculus removal were foreseen.

### [6.2.2.2 Quality of treatment restricted by infrastructure](#)

The quality of the offered treatment suffered because of the limited infrastructure present at the treatment site. As no dental chair, no electrical engine, no materials for surgical extractions and only glass ionomer fillings were present, the quality of the treatments was restricted. When no treatment seemed appropriate because of the circumstances, the children were referred to a higher level. As the dental treatment and transport to the closest oral health care service is not affordable for most people of Kerung (Addendum 2.1), there was no guarantee that the children would be able to get treatment. As a consequence, the authors of this study are aware that pathology was left behind.

## [6.2.3 Opportunities](#)

### [6.2.3.1 Sponsoring](#)

As the project was an initiative by the company Septodont, they supported the entire project on a financial and logistical level. The Department of Paediatric Dentistry of the University Hospital in Ghent provided mirrors, probes, plaque disclosing tablets, gauze and developed all educational materials. DentalPharma delivered the gloves and masks used for the clinical examination and Colgate sponsored the project by supplying 800 tubes of toothpaste and the same amount of toothbrushes. Financial support was also received from Soroptimist International, who sponsored the development of educational materials.

### [6.2.3.2 Collaboration and communication](#)

A good communication and collaboration between all active parties was maintained throughout the whole project.

### [6.2.3.3 Kerung](#)

The inhabitants of Kerung were very receptive and grateful to be part of the project. The children, as well as their parents, were very welcoming. The cooperation with the school was excellent and favourable for the project. The school staff lifted the project to a higher level e.g. the idea of adding the developed brushing song to the routine of the morning ceremony was a proposal made by a school teacher.

## [6.2.4 Threats](#)

### [6.2.4.1 Nepalese authorities](#)

As previously mentioned, the authorities of Nepal do not provide enough jobs for dentists, leading to a large unemployment rate of dentists and consequently a lack of availability of oral health prevention and oral health care (Addendum 2.2). In addition, no permission from the government was granted to the Belgian dentists to treat the Nepalese children in this project.

### [6.2.4.2 Kerung](#)

The customs of the inhabitants of Kerung turned out to be different in comparison to Belgium. Regarding the school logistics and organisation, the approach could be considered as less strict e.g. the school had no updated list of the children attending the school and not all children got assigned an identification number. A lot of children did not know their own date of birth. As a consequence, some difficulties were encountered matching the children at T0 and T1, aside from the fact that at T1 some children were new and other children had departed from the school. As the project was implemented, the English level of the children in Kerung was lower than expected. The language barrier was mostly overcome by the Nepalese dental team, who was always eager and willing to help with translating. As a consequence of Kerung being a remote village and not being easily accessible, it is difficult to transport oral health care materials to the village. As a lot of candy, chips and other sugary snacks were sold at the local shops in Kerung, a Western influence is noticeable on the sugar exposure.

## [6.2.5 Future perspectives](#)

When implementing an oral health project in an emerging country, focus should be put on prevention and oral health promotion, aside from treating existing oral health problems. In

future studies, to achieve hard evidence on the effect of an oral health program, it is recommended to use a randomized study design including a control group. As pit and fissure sealants are a possible way to prevent development of dental caries, this could be added to similar projects implemented in the future. With regard to offering the best possible care, it is recommended to bring appropriate materials for treating all present pathology. For instance, a mobile dental chair including an electrical engine to treat non-cavitated carious lesions, biocompatible and bioactive materials to treat progressive dental caries and surgical extraction materials could be valuable in future projects.

The authors are pleased to confirm that the project will be continued for another two years, taking into account the aforementioned recommendations.

## 7. CONCLUSION

The findings in the present study made clear that there was a high caries prevalence and a low oral cleanliness present in young age children and adolescents in Kerung, Nepal. Moreover, it was shown that there was a negligible amount of fluorosis, erosion, malocclusion, untreated dental trauma, MIH and developmental disorders in this population. In addition, it was obvious that there was insufficient knowledge about oral health and there were inadequate brushing and nutritional habits. However, a clear effect of the collected data on OHRQoL was not found.

During the intermediate period of six months between T0 and T1 the children were provided with toothbrushes and toothpaste. At T1, it was clear that dental screenings, treatments and a comprehensive educational program (including a theoretical lesson, plaque disclosing and a practical brushing session, educational materials such as posters and other materials for playful learning, a leaflet with recommendations for the parents and a teach-the-teacher booklet) significantly influenced oral health. This was especially reflected in a significant decrease of plaque and caries prevalence. Few significant effects were found in the oral health habits and nutritional habits.

A positive answer could be given to the predetermined PICO questions. Taking into account the above mentioned findings, the H0 hypothesis could be accepted and consequently H1 was rejected for the following parameters: caries prevalence, quantity of plaque and oral health knowledge. The H0 hypothesis for oral health and nutritional habits could be partially accepted.

This study can potentially encourage further research and organising analogous dental camps to pursue reliable baseline data on a large scale and evaluate the effects of oral health education among schoolchildren in remote areas in Nepal.

## 8. NEDERLANDSE SAMENVATTING

### 8.1 Doelstelling

Het doel van deze studie is tweeledig. Het eerste doel bestaat uit het cross-sectioneel beschrijven van de huidige mondgezondheidssituatie, de kennis omtrent mondgezondheid, de mondgezondheidsgewoonten en de mondgezondheidgerelateerde levenskwaliteit van de kinderen in Kerung, een afgelegen bergdorp in Nepal. Het tweede doel bestaat uit het prospectief evalueren van voorgenoemde gegevens zes maanden na het geven van een mondgezondheidsprogramma.

### 8.2 Materiaal en methoden

Een prospectieve case series werd opgezet, bestaande uit twee momenten van uitgebreide epidemiologische cross-sectionele dataverzameling. Het Ethisch Comité van zowel België als Nepal gaven hun goedkeuring voor het project. Voor de start van het project werd een literatuurstudie uitgevoerd om een basiskennis te verkrijgen alsook de hiaten in de literatuur op te sporen. Na het verkrijgen van informed consent, werd een selecte steekproef op basis van beschikbaarheid bekomen, bestaande uit de kinderen van de lokale school in Kerung. Er werden twee meetmomenten gepland in Kerung met een tussenperiode van zes maanden. Op tijdpunt 0 (T0) werden 359 kinderen met een gemiddelde leeftijd van 13.24 jaar oud (range: 2 – 22 jaar oud) onderzocht en op tijdpunt 1 (T1) werden 339 kinderen met een gemiddelde leeftijd van 13.14 jaar oud (range: 2 – 24 jaar oud) opgenomen in het onderzoek. 266 kinderen van de onderzochte groep op T0 namen ook deel aan het onderzoek op T1. Op beide meetmomenten werden de kinderen klinisch onderzocht en werden er drie vragenlijsten van hen afgenomen. Het klinisch onderzoek bestond uit gevalideerde indexen om plaque, cariës, klinische gevolgen van onbehandelde cariës, erosie, trauma, fluorosis en molar-incisor hypomineralisation te evalueren. Ontwikkelingsstoornissen en malocclusie werden ook genoteerd. De onderzoekers werden gekalibreerd. De drie vragenlijsten hadden respectievelijk betrekking op de kennis, de mondgezondheidsgewoonten en de mondgezondheidgerelateerde levenskwaliteit van de kinderen. Naast het verzamelen van de gegevens werd een mondgezondheidsprogramma ontwikkeld, gericht op preventie van mondgezondheidsproblemen door het aanleren van goede mondgezondheidsgewoonten, zowel in theorie als praktijk. Het educatief programma bestond uit een theoretische les, plaque-onthulling met een praktische poetsessie, leermateriaal zoals posters en materialen om spelenderwijs te leren, een folder met aanbevelingen voor de ouders en een teach-the-teacher bundel. Wanneer pathologie gevonden werd tijdens het klinisch onderzoek, werd deze door een meereizend team van Nepalese tandartsen behandeld. Glasionomeer vullingen werden geplaatst en indien noodzakelijk werden tanden geëxtraheerd. Op het tweede meetmoment

werd ook materiaal voorzien om tandsteen te verwijderen. Uit de cross-sectioneel verzamelde gegevens werden 266 kinderen geïncludeerd in het gepaard prospectief onderdeel van het project. Deze kinderen waren gemiddeld 12.88 jaar oud met een minimale leeftijd van 2 jaar en maximale leeftijd van 20 jaar.

### 8.3 Resultaten

Op T0 werd bij de onderzochte kinderen een cariësprevalentie van 79.0% gevonden. De gemiddelde DMFT/dmft bedroeg 9.16 en werd gedomineerd door de D/d component. De gemiddelde D<sub>1</sub>MFT/d<sub>1</sub>mft en D<sub>3</sub>MFT/d<sub>3</sub>mft bedroegen respectievelijk 4.65 en 3.48. Een hoge behandel nood werd vastgesteld. De gemiddelde plaque score bedroeg 0.77. Algemene kennis rond mondgezondheid bleek laag. Daarentegen bleken de kinderen een positieve attitude te hebben ten opzichte van mondgezondheid. 76.4% van de kinderen gaf aan minstens twee maal per dag te poetsen en 81.9% vermeldde minimum twee minuten te poetsen. 58.8% en 16.2% van de kinderen verkondigde minstens één maal per dag respectievelijk een suiker bevattend tussendoortje of een stuk fruit te nuttigen. Blootstelling aan suikerrijke dranken bleek hoog. Respectievelijk 45.7% en 33.2% van de kinderen rapporteerde dagelijks minstens één eenheid frisdrank of fruitsap te drinken. Meer dan de helft van de ondervraagde kinderen (61.4%) had ooit tandpijn of pijn in de mondholte ervaren. Op T1 werd vastgesteld dat 38.7% van de kinderen tandsteen had. 41.7% van de kinderen gaf aan dagelijks gesuikerde thee te drinken. Kennis omtrent mondgezondheid werd verkregen via school, ouders en/of de media.

Na het mondgezondheidsprogramma was een statistisch significante daling meetbaar in de gemiddelde plaque score. De gemiddelde daling bleek significant hoger voor jongens dan voor meisjes. Een significante daling in cariësprevalentie was waarneembaar, alsook een statistisch significante stijging in de kennis rond mondgezondheid. Op T1 werd een significant hoger percentage kinderen gemeten die minimaal twee minuten hun tanden poetsten.

### 8.4 Conclusie

In deze studie werd op T0 een hoge cariës prevalentie en een slechte mondhygiëne gevonden bij de kinderen van de lokale school in Kerung. De prevalentie van fluorosis, erosie, malocclusie, onbehandeld dentaal trauma, molar-incisor hypomineralisation en ontwikkelingsstoornissen bleek verwaarloosbaar in deze populatie. Daarnaast werd ook duidelijk dat er onvoldoende kennis heerste rond mondgezondheid en de kinderen inadequate mondgezondheids- en nutritionele gewoonten vertoonden. Van deze gevonden informatie kon echter geen effect aangetoond worden op de levenskwaliteit.

Na een tussenperiode van zes maanden, waarin de kinderen voorzien werden van tandenborstels en tandpasta, werd duidelijk op T1 dat klinisch onderzoek, noodbehandelingen en een uitgebreid educatieprogramma de mondgezondheid significant beïnvloedden.



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