

# Screening Test for Olfactory Function: A New Tool Validated in Nepalese Children

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## ABSTRACT



**Background:** Olfactory function disorders adversely affect the growth and development of children and it increases the risk of various injuries and hazards. Despite a significant problem, this area has been neglected and there is no single cross culturally validated tool to evaluate olfactory function of Nepalese children. This study was designed to determine the order recognizable by Nepalese children, which could be used as a screening test tool for olfactory function.

**Methods:** A total of 130 children age ranging from 4 to 10 years from six schools of Kathmandu valley were examined. (Sampling) All students of Nursery to grade 4 were divided into three age groups and tested separately for 22 different odors for the olfactory function. The tested objects were locally available fruits, spices, alcohol, kerosene, baby powder etc. that were selected on the basis of their familiarity with Nepalese children. The objects were kept in a dark labeled coded bottle and unscrewed for smell under nose of each child and at the same time a show card was shown having three pictures including the correct one. The child was then asked to point out the correct answer and was recorded. From the most recognized 12 odors, 7 odors were selected which exceeded the minimum threshold for a proposed screening tool. After two weeks, a revalidation test was carried out among 45 children (15 from each age group) in same schools by using 7 odors in four-fold repetition in order to determine the real identification of odor.

**Results:** Among the 22 objects or odors tested, a 75% recognizability threshold was exceeded by 12 odors. From these 12 odors, 7 most recognized odors (apple, banana, lemon, fish, chocolate, soap and coconut) were selected for a proposed screening test tool. Retesting of the chosen odors showed satisfactory test-retest reliability, split half reliability and validity of the 7 odors test.

**Conclusion:** We found 7 odorants, which were commonly familiar to Nepalese children and can be used to determine the orthonasal olfactory function of Nepalese children. This test is easy, quick, non-interventional and cost effective in resource restricted clinical practice setting like in Nepal

**Keywords:** Smell, Odor, Olfactory screening tool, Smell identification test, Nepal

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## BACKGROUND

The response to odor begins inside mother's womb before birth when a baby is floated in amniotic fluid.<sup>1</sup> Research shows that infant and small children are capable to recognize as well as distinguish smell, which helps them to get information about various food items and their surrounding environment.<sup>2</sup> The development of olfactory function increases with the exposure to various objects of their surroundings and environment. Normal olfactory function can be regarded as an indicator for a normal child growth and development.<sup>3</sup>

The olfactory bulb contains neuroepithelium cells that are mainly linked with the olfactory nerve (1<sup>st</sup> cranial nerve) and are responsible for odor sensation and determining flavors. The somatosensory sensations like hotness, coldness and irritations from nasal mucosa are determined by trigeminal somatosensory intranasal system via trigeminal nerve (5<sup>th</sup> cranial nerve). Thus, for normal olfactory function, both the 1<sup>st</sup> and the 5<sup>th</sup> cranial nerve must be intact.<sup>4</sup> Normally, odors can be perceived by two ways: ortho-nasal via nostril during inhalation and retro-nasal via mouth during eating, drinking or deglutition.<sup>5</sup>

The olfactory function disorders can seriously impact on quality of life.<sup>4</sup> Disturbance on smell function can adversely affect the daily life. Food preferences, appetite, emotional memory, sexual bonding and psychological depression are influenced by olfactory function.<sup>6,7</sup> Olfaction also has an important role in safety and prevention from various injuries and environmental hazards for example, spoiled foods, leaking cooking gas, smoke and various airborne pollutants.<sup>7,8</sup>

Few studies have been found on prevalence and incidence of olfactory function disorder. The incidence of olfactory function disorder in elderly population aged over 65 years is estimated to be 50 %<sup>4</sup> and the problem is usually found in elderly population than in

children.<sup>4</sup> There has been no any study found yet about the prevalence of anosmia (loss of smell) in children however it is estimated that about 6 percent of population suffers from anosmia.<sup>9</sup> And about 20 % of the general population has impaired olfactory function (hyposmia).<sup>9-11</sup>

Loss of smell or disturbance in olfactory function has multi factorial etiologies. The most common conditions of olfactory function disorders in children are allergies, nasal and sinus diseases, upper respiratory tract infections, severe head injuries, and hormonal disorder.<sup>4</sup> Sometimes, a congenital anosmia called Kallmann's Syndrome can be a condition where children loss the ability to smell.<sup>12</sup> Some study also shows that long-term exposure of many environmental toxic agents and pollutants can also cause damage to neuroepithelium which can influence the olfactory function.<sup>7</sup> Pre natal exposure to alcohol and olfactory function deficit in children also shows the association in study.<sup>13</sup> A number of different tests and ways ranging from simple to sophisticated types are now available to evaluate the olfactory function of children and adult. Different types of Psychophysical, electro- physiological tests along with structural and functional imaging procedures have been developed to quantify olfactory function.<sup>14</sup> In this context, there is no single cross culturally validated tool available in Nepal to measure the olfactory function of Nepalese children and in our knowledge there is no study in this area to date. Even in routine clinical practice this test has been neglected for the small children. Evaluation of olfactory function in children is important as it could hamper their normal growth and development. The early identification of a problem could help them to lead quality life as well as it also help to identify the pre-clinical condition of neurodegenerative diseases. Several standard tools that are being developed to measure the

olfactory function are not easily available in the context of Nepal and importantly are not suitable for the Nepalese children because of the unfamiliarity of the odors. Thus, we initiated this study for the first of its kind to find out the commonest objects which are familiar to Nepalese children and which could be used in screening olfactory function test.

## MATERIALS AND METHODS

**Study design:** This was a descriptive cross sectional study carried out in 6 schools of Kathmandu valley from April 2015 to July 2015. Kathmandu valley, made up of three districts Kathmandu “the Capital city”, Lalitpur and Bhaktapur and is a most populated place of Nepal, rich in diversity of culture and ethnicity.<sup>15</sup>

**Sampling:** Two schools from each 3 districts were included representing one private and one public school. The schools were first divided into two categories private and public in each district then one school from each category was selected by lottery method.

Children currently studying in grade 1 to 3 and who were between the age of 4 and 10 years were selected as study sample. Children having history of chronic illness, neuro - developmental impairment, chronic sinusitis, rhinitis, Deviated nasal septum (DNS), nasal polyps, and history of severe head injury were excluded. Every child was undertaken the laryngological examination to avoid any illness that can influence the olfaction. After confirmation of having no any chronic illnesses and no any disorder of olfaction children were recruited in the study. In case of abnormality children were sent to the medical consultation. Altogether, 10 students were not included in the study because of the throat infection and headache during the time of examination. Trained enumerators of medical background carried out data collection and physical examination.

## Selection of object for smell and Test procedure

At the beginning, 22 different objects were identified for the olfactory function test. Among 22 objects 17 were already being used in different standard international tools (Sniffin Stick test, UPSIT, CCCRC, CC-SIT)<sup>16-19</sup> whereas five objects (onion, kerosene, alcohol, chewing tobacco and coriander) were added according to the familiarity of objects among Nepalese children. The objects, thus added, were discussed with pediatrician, otolaryngologist and psychologist of Nepal before including in the test. We accepted the widely followed norm in olfactory function studies that any odor which is accurately recognized by 75% of healthy population is thought to be the threshold to include the odor in olfactory test.<sup>16</sup>

Among 22 objects 5 were fruits and we took a locally available ripen fresh whole fruit (with bark and seeds) and chopped them firmly so that the natural aroma can be administered. Matured and fresh tuberous root of garlic, onion and ginger, fresh fish, rose flower, fresh coriander green leaves were also chopped in a same way as did with the fruits. For alcohol, a commonly available brand of whisky “Royal Stage” was used. For baby powder Johnsons’ brand was used and for chocolate we used Choco Fun brand. OK brand for soap, Super power brand for chewing tobacco and locally available kerosene were used. We chopped the entire solid item in small pieces and kept in an airtight bottle whereas liquid and powder were kept as it was. The characteristic smell of spices and fruit can be obtained after destroying the tissue or by cutting the fruits.<sup>20</sup> For the uniformity of the test we used the same quality and amount of items throughout our study period. Bottle were rinsed with detergent every day after completion of data collection and dried before re using them to avoid extraneous odor.

The objects were kept in a dark glass bottle, labeled and coded. The unscrewed bottle was moved over both nostrils for 3 seconds in a distance of 2 cm from the nostrils. For each target odor, children were shown a card having three pictures in which one of them was the correct odor and rests of the two were distracters. Each picture was labeled in local Nepali language and the names were read to the children at the beginning of the test every time. The child was then asked to identify the odor by pointing to the picture from three possible options. The answer given by the children by indicating the picture were recorded. We took a minimum time interval of 30 s to present each odor.<sup>21</sup> The test was carried out in a quiet room free from extraneous odor.

From the most recognized 12 odors, 7 odors were selected which exceeded the minimum threshold for a proposed screening tool. After two weeks, a revalidation test was carried out among 45 children (15 from each age groups of 4-6 yrs, >6-8 yrs and >8-10 yrs)) by using 7 odors in four-fold repetition in order to determine the real identification of odor each time.

This study fully complied with the ethical guidelines of the Nepal Health Research Council (NHRC). It was approved (Ref.No.1869) by National Ethical Review Board (ERB) at the NHRC. A formal consent was taken from the school authority, and a written informed consent was taken from the participants and their parent prior to the test.

Data were entered and analyzed by using IBM SPSS statistics 23-version program. Percentage, Chi squared Pearson's correlation coefficient (C), Linear correlation(r) were applied for the assessment of interrelations within the data and Z test for proportion for reliability and validity.

## RESULTS

General characteristics of the children participated in the study is described in table1. Findings revealed that distribution of the children in each sub groups were almost equal. It was 33.2 to 33.8% in three age groups, 50.8% were male and by ethnic majority were from Janajati followed by Brahmin/ Chhetri and Dalit. Statistical analysis showed that sex ( $p = 0.318$ ;  $C = 0.088$ ) and ethnicity ( $p=0.907$ ,  $C= - 0.01$ ) had no influence on the identifiable number of odors. An exception was zinger that was more recognized by girl than boys ( $p = 0.047$ ;  $C = 0.174$ ) although the statistical differences were very weak. Age, however did influence on identification of the number of the odors ( $p < 0.001$ ;  $r = 0.624$ ). Moreover, there was a statistically significant influence of three age groups on the number of odors identified ( $p < 0.001$ ;  $C = 0.59$ ). However, only in the group of youngest children, below the age of 6, significant correlation of age with olfactory test result was observed ( $p = 0.013$ ;  $r = 0.372$ ). As seen in Table 2, the average number of the odors accurately identified by the three age groups children were 13 (59.1%) in Group 1, 17(77.3%) in Group II and in Group III 19(86.4%) whereas the average number of the odors accurately identified by the total group or all children was 16.5(75%).

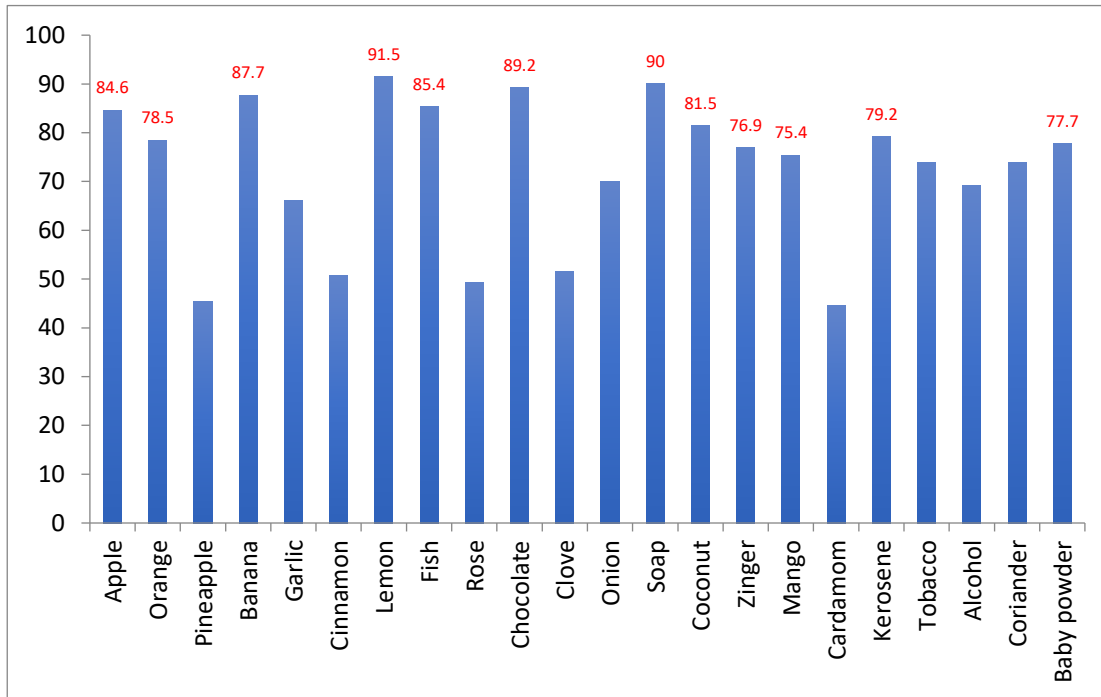
The percentage distribution of children who accurately identified particular odor is shown in figure 1. The odor of lemon, soap and chocolate had the highest level of recognition (the accurate answers provided respectively by 91.5%; 90%; 89.2% of all subjects) and the least recognized were cardamom (44.6%) and pineapple (45.4%). Among 22 odors tested by 130 children, the 75% recognizability threshold was exceeded by 12 odors in average (group I – 7 odors, group II – 14 odors, group III – 17 odors).

**Table 1. General characteristics of the study population (n =130)**

Variables	Description	Number	Percent	Ethnicity	Girls	64	49.2	
Age group	4-5 yrs	44	33.8	y	Brahmin	/	44	33.8
	6-8 yrs	44	33.8		Chhetri			
	9-10 yrs	42	33.2		Janajati	77	59.2	
Gender	Boys	66	50.8	Total	Dalit	9	6.9	
						130	100	

**Table 2: Odor identification accuracy by children in three age groups**

Odors	GROUP I <6 years old (44 persons)			GROUP II 6-8 years old (44 persons)			GROUP III >8 years old (42 persons)			
	4 years (18 persons)	5 years (26 persons)	Summary persons (% of the group)	6 years (15 persons)	7 years (20 persons)	8 years (9 person s)	Summary persons (% of the group)	9 years (33 persons)	10 years (9 persons)	Summary persons (% of the group)
Apple	15	21	36(81.8%)	12	17	8	37(84.1%)	29	8	37(88.1%)
Orange	13	15	28(63.6%)	11	19	7	37(84.1%)	28	9	37(88.1%)
Pineapple	9	8	17(38.6%)	6	8	5	19(43.2%)	18	5	23(54.8%)
Banana	13	24	37(84.1%)	14	17	7	38(86.4%)	30	9	39(92.9%)
Garlic	8	15	23(52.3%)	8	11	8	27(61.4%)	30	6	36(85.7%)
Cinnamon	3	11	14(31.8%)	6	11	7	24(54.5%)	20	8	28(66.7%)
Lemon	11	25	36(81.8%)	15	20	6	41(93.2%)	33	9	42(100%)
Fish	13	24	37(84.1%)	11	17	9	37(84.1%)	29	8	37(88.1%)
Rose	8	13	21(47.7%)	3	9	5	17(38.6%)	20	6	26(61.9%)
Chocolate	16	21	37(84.1%)	15	17	9	41(93.2%)	29	9	38(90.5%)
Clove	3	11	14(31.8%)	6	10	7	23(52.3%)	23	7	30(71.4%)
Onion	11	17	28(63.6%)	8	15	5	28(63.6%)	29	6	35(83.3%)
Soap	14	22	36(81.8%)	13	20	8	41(93.2%)	32	8	40(95.2%)
Coconut	13	20	33(75%)	12	15	7	34(77.3%)	30	9	39(92.9%)
Zinger	9	21	30(68.2%)	11	16	8	35(79.5%)	28	7	35(83.3%)
Mango	10	20	30(68.2%)	12	16	6	34(77.3%)	28	6	34(81%)
Cardamom	3	8	11(25%)	8	9	4	21(47.7%)	19	7	26(61.9%)
Kerosene	10	16	26(59.1%)	13	16	9	38(86.4%)	30	9	39(92.9%)
Tobacco	6	14	20(45.5%)	12	17	8	37(84.1%)	30	9	39(92.9%)
Alcohol	5	12	17(38.6%)	12	16	9	37(84.1%)	28	8	36(85.7%)
Coriander	11	15	26(59.1%)	10	14	7	31(70.5)	31	8	39(92.9%)
Baby powder	11	18	29(65.9%)	13	15	8	36(81.8%)	28	8	36(85.7%)
An average number and % of recognized aromas	13(59.1%)			17(77.3%)			19(86.4%)			

**Figure 1: Percentage of all the children accurately recognizing a particular odor**

From the most recognized 12 odors, we selected the highest recognized 7 odors (apple, banana, lemon, fish, chocolate, soap and coconut) and analyzed by exposing them to all the children's response. The analysis of all children's responses after exposing them to smell of the proposed screening test showed that – 54 persons (43.8%) accurately recognized all 7 odors, 47 (36.9%) – 6 odors, 7 (8.5%) – 5 odors, and 18 (8.5%) – 4 odors respectively. According to the accepted norm of 75% recognizability threshold, the correct identification of 75% of test odors that is at least 5 out of 7 olfactory stimuli used in the screening test was accepted as a norm. The threshold was exceeded by proposed 7 odors and the norm was achieved by 89.2% of the examined children.

We employed the statistical analysis based on test Z for proportion for reliability and validity of the final 7 odors test on the assumption that satisfactory level of specific odor recognitions was 90%. Validation data obtained from each

group have been shown in Table 3. The result shows the appreciable age trend on variability of score on accurate identification of odors. Among three groups, in-group I and II the odor- coconut show statistically significance different in odor identification level in comparison to the assumption level (90 %) however if we decrease the assumption level to 80 % then there is a good recognition of odors in all age group of children.

After two weeks, revalidation of the proposed final test of 7 odors was carried out among 45 children (15 from each age group). Children were given the 7 odors in four-fold repetitions tests in order to determine the real identification of odor each time. After familiarizing children with 7 odors, the odors were tested again but in mixed pattern. So the same odor cannot be recognized serially. Results showed satisfactory test-retest reliability, split half reliability and validity of the 7 odors test.

**Table 3: Variability of score on accurate identification of odors among three groups**

7-odors test	Group I			Group II			Group III		
	Recogni tion	Error	Test Z for proportion (p value)	Recogn ition	Error	Test Z for proportion (p value)	Recogni tion	Error	Test Z for proportion (p value)
Apple	36	8	0.0704	37	7	0.1914	37	5	0.6807
Banana	37	7	0.1914	38	6	0.4214	39	3	0.5371
Lemon	36	8	0.0704	41	3	0.4817	42	0	1
Fish	37	7	0.1914	37	7	0.1914	37	5	0.6807
Chocolate	37	7	0.1914	41	3	0.4817	38	4	0.9181
Soap	36	8	0.0704	41	3	0.4817	40	2	0.2578
Coconut	33	11	0.0009	34	10	0.0049	39	3	0.5371

## DISCUSSION

The result shows that a significant number of children recognized the proposed 7 odors use to evaluate olfactory function among Nepalese children. The proposed tool was developed and validate among Nepalese children by applying same tool validation method as it was carried out in Poland <sup>12</sup> to develop a test for screening olfactory function in polish children.

We proposed a 7 odors (apple, banana, lemon, chocolate, fish, soap and coconut) screening tool for the children age 4 – 10 years of age group. Like other studies, <sup>6,12</sup> gender of the children did not influence the odor identification. We also looked if, ethnicity influenced the odor identification since in Nepal, a caste system exists and populations are categorized according to their caste in different ethnic groups. We categorized the subjects in three ethnic groups; <sup>22</sup> the upper caste (Bramin and Chhetri), the lower caste Janajaati (disadvantaged group) and Dalit (water unacceptable caste). However, no influence of ethnicity on odor recognition test

was observed. This suggests that the tool is suitable in children of all ethnic group of Nepal.

Our finding about the influence of age is consistent with previous studies which reported that with increasing age of children, the number of odor identification was also increased. <sup>6,12,23,24</sup> The present study also showed that the average number of odor identification in three age groups of two years difference age from 4 to 10 years, were 13,17 and 19 respectively and the number of identified odor exceeding 75% recognizability threshold were also increasing from 7 to 14 and to 17 respectively in three age groups.

Regarding the source of odors, the materials used in various standard tools are not suitable to Nepalese children because of the cross-cultural variation and uncommonly used objects in daily life. For example, many of the tools consist of the odors of strawberry, coffee, popcorn, cola, mint, vanilla, play doh etc. Thus, we choose the natural object of the daily life as the source of odor. For the intensity and

the threshold of the odor, a few numbers of children were examined for the best smelling from different amounts of fresh cut fruits and other materials. We found that the children easily recognized 50 gm. or 50 ml. of an item so we used the same amount and quality of odor item throughout our study to maintain the uniformity. We also followed the important protocol for odor studies stating that the odor testing should be carried out within a nominal time period of 24 hour of sample collection.<sup>25</sup> That is why, we took every item for only 6 hour a day to ensure the better intensity of the odor. Odor identification involves both sensory and cognitive functions, and it require mainly of three processes<sup>26-30</sup>. Firstly, a certain degree of olfactory sensitivity for detection of any odor, Secondly, accurate recognition of the odorant<sup>31</sup>, and lastly a search through semantic stores for the appropriate verbal label to express by naming the odorant<sup>32</sup>. Thus, based on these combined processes only we can perceived a holistic odor at a conscious, perceptual state<sup>33</sup>. Smelling ability of human is very active at detecting odors and can discriminate between tens of thousands of odors<sup>34</sup>. At the same time, naming that odor seems a very difficult task<sup>35</sup>. Usually people are able to smell an odor and recognize it as familiar, however are still not able to produce a specific verbal label<sup>36</sup>. Moreover, when given the name of the odor afterwards, the odor can be recognized immediately<sup>36</sup>. In our study the same rule followed. After administering an odor child were asked to point out the best suitable odor in the picture. The enumerators read loudly each time for identification of odor and if requested by participants, with repetitions. Identifying an odor verbally is being discouraged because poor odor identification performance could be because of a weak link between odor and language<sup>35,37</sup>. Thus, the test seems dependent on cognitive processes associated with

learning and memory, important for a wide range of cognitive functions apart from odor recognition. At the same time, it is evidence that the pictorial response format and the selection of more familiar items of odor to children help to reduce the possible potential confounding of cognitive or developmental influences<sup>38</sup>. So our present test seems good from both aspects.

Similarly, there are various types of testing tools available, which are validated in the western world. The UPSIT consists of 40 "scratch and sniff" odorants<sup>17</sup>. B-SIT (also known as CC-SIT), a short validated version of the UPSIT, contains 12-item<sup>19</sup>, Sniffing Sticks screening Test (SSSIT) also a 12-item screening version<sup>16</sup>. In this context, our proposed screening test tool consists of 7 odors and is easy to administer as well as it took a very short time period of 4-5 minutes to complete in comparison to another tool. In the present study it took 10-12 minutes for whole 22 objects to test. Most importantly the proposed tool is very cost effective and easily available and author think it is very useful in resource constraint setting health centers like Nepal.

The limitations of our study were relatively the small sample size to represent the large population and yet the tests need to be strictly adjusted to an age group. Furthermore, in our present study, we focused on the importance of shaping perception of an odor in children by administering natural odorants, however, as planned, we recommend to substitute the natural stimuli with the chemical fragrance for more accurate threshold and intensity of the odors, which also increases the tools' reliability and validity.

Furthermore, the present proposed 7 odor screening test is purely noninvasive in nature and is very quick and easy to apply. As we found a good performance of the children and on the basis of our experience it can be said



that the test has good subject acceptance. In the present study, all subjects readily agreed to participate and were enthusiastic to try the odors like a game. In this present study, we widely accepted the norm that recognition of an odor by 75% of the healthy population is thought to be the threshold to include that odor in olfactory test<sup>16</sup>.

The sense of smell is influenced by various factors such as experience and culture, and feasible tools<sup>29</sup>. And therefore, it is the need to validate the tool before using it as a diagnostic purpose in any specific population.

## CONCLUSION

The seven odors, which were easily identified by 4 to 10 years old children, were the odor of Apple, Banana, Lemon, Fish, Chocolate, Soap and Coconut. Children performed well with the test and the test showed the normative data and also had good reliability and validity. This test seems easy, cost effective and may be useful in clinical practice of resource constraint setting like in Nepal. In conclusion overall finding suggests that it is now possible to evaluate olfactory function of a child by using our proposed tool in Nepalese context

## List of Abbreviations

DNS-Deviated Nasal Septum

UPSIT-University of Pennsylvania Smell Identification Test

CCCRC-Connecticut Chemosensory Clinical Research Center

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CC-SIT-Cross-Cultural Smell Identification Test

## Ethics approval and consent to participate

Ethical approval was obtained from Nepal Health Research Council of Nepal and REK Norway. The study was conducted on the guidelines in the Declaration of Helsinki. Written consent was obtained from both parent and their children.

## Authors' contribution

RP was involved in the acquisition of data, analysis of data and writing of the manuscript. NT and BSP provided advice for the design and conceptualization of the study and analysis of data. PT, KA, PT were involved in data analysis and manuscript writing. BSP supervised the study and was involved in study design, data analysis and critical revision of the manuscript for intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspect of the work.

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