Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

American Journal of Otolaryngology–Head and Neck Medicine and Surgery 42 (2021) 102872

Contents lists available at ScienceDirect

American Journal of Otolaryngology–Head and Neck Medicine and Surgery

journal homepage: www.elsevier.com/locate/amjoto

A comparison of swab types on sample adequacy, suspects comfort and provider preference in COVID-19

Vijay Bidkar, MS (ENT), Associate Professor [a,*], Kalaiselvi Selvaraj, MD, Assistant Professor [b], Meena Mishra, MD, Professor [c], Vishal Shete, MD, Assistant Professor [c], Anita Sajjanar, MD, Associate Professor [d]

[a] Department of Otorhinolaryngology-Head and Neck Surgery, All India Institute of Medical Sciences, Nagpur, Maharashtra, India
[b] Department of Community Medicine, All India Institute of Medical Sciences, Nagpur, Maharashtra, India
[c] Department of Microbiology, All India Institute of Medical Sciences, Nagpur, Maharashtra, India
[d] Department of Pathology, Datta Meghe Medical College, Nagpur, Maharashtra, India

ARTICLE INFO

Keywords:
Coronavirus Infections/diagnosis
SARS
Pandemics
Pneumonia
Viral/diagnosis
Specimen Handling
Sensitivity and Specificity
Nasal Cavity

ABSTRACT

Aim: This study was aimed to compare the virological, suspect reported outcomes and provider preferences during COVID-19 swab taking procedure used for sampling.

Methods: The COVID-19 suspects are subjected to nasopharyngeal (NP) and oropharyngeal (OP) swabs for testing. Two types of swabs (Nylon and Dacron) are used for sample collection. Prospectively each suspect's response is collected and assessed for self-reported comfort level. The provider's experience with each suspect and virological outcomes recorded separately. The sample adequacy was compared based on swab types and demographic characteristics.

Results: A total of 1008 COVID-19 suspects were considered for comparison of various outcomes. Dacron and flocked Nylon swab sticks are used for taking 530 and 478 samples, respectively. Suspects who underwent the procedure using Nylon swabs were six times more likely to have pain/discomfort compared to when Dacron swab was used (Adj RR (95% CI: 6.76 (3.53 to 13, p=0.0001))). The providers perceived six times more resistance with the Nylon swabs compared to Dacron Swabs (Adj RR (95% CI: 5.96 (3.88 to 9.14, p=0.0001))). The pediatric population had a higher rate of blood staining in Dacron swab [Dacron 66 (80.5%); Nylon 51 (54.8%) p=0.0001]. The sample adequacy rate and laboratory positivity rate were not significantly different from each other.

Conclusions: Given the comparable virological outcomes, the difference in suspect and providers comfort should drive swab selection based on characteristics of the suspects. The bulbous Nylon swab caused more pain/discomfort in adults compared to Dacron.

1. Introduction

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) or Coronavirus Disease 2019 (COVID-19) has disrupted lives in many ways. The World Health Organisation (WHO) has announced COVID-19 as a Public Health Emergency of International Concern on January 30, 2020.

Our experience of a similar but less infectious viral pandemic, the Spanish Flu at the beginning of the nineteenth century, or more recent SARS-CoV and MERS are relatable. They have helped us to create mathematical models for contact tracing and follow up, which are useful for establishing measures to control of transmission while navigating through the pandemic [1]. However, there are unique challenges in the twenty-first century. The fast-paced life has led to the rapid spread of the virus across the globe. Together this and the higher infectivity of COVID-19 is testing the strength of the health care system. At the very beginning of the pandemic, the specialty of otorhinolaryngology was called upon for taking samples of the suspects. Subsequently, health care workers (HCW), including nursing, laboratory technicians were trained to do this task. The crucial step of sample collection includes various processes such as the specimen collection, packaging, storage, and transportation, which can influence results [2]. The yield of the diagnosis is dependent on multiple factors. Since these repurposed providers are not as familiar

* Corresponding author.
E-mail address: dr.vijaybidkar@gmail.com (V. Bidkar).

https://doi.org/10.1016/j.amjoto.2020.102872
Received 20 November 2020;
Available online 29 December 2020

as the medical professionals regarding anatomical relations of the respiratory tract. The incidences of mild injuries, discomfort are expected to be more.

The health system envisages achieving optimum technical efficiency even with these deployed or repurposed health professionals. However, repeated and prolonged exposures to the positive cases might increase the risk for cross-infection in these HCW. As the provider has to offer uninterrupted services during this time, it is advisable that all HCW should understand these nuances of the procedure and strictly administer the suggested guidelines. This will ensure the prevention of the cross infection.

Currently, the Indian Council of Medical Research (ICMR) has accredited two types of swab collecting material, namely, Dacron and Nylon. The differences in the structure of these two swabs are expected to influence the suspect reported outcomes such as comfort and procedural challenges for the HCW provider.

In this circumstance, this study is aimed to analyse the disaggregated performance of these two swabs in terms of the sample adequacy, comfort level perceived by the COVID-19 suspects undergoing the swab procedure, and comfort level of the providers. This will help in making appropriate decisions to choose the context-specific swab for sampling procedure.

2. Material & method

2.1. Study design

This is a facility-based analytical study. It was performed among prospective COVID-19 suspects attending COVID-19 quarantine centres and outpatient clinics treating the patients with Influenza-like Illness (ILI) and Severe Acute Respiratory Infection (SARI).

2.2. Study setting & study population

We compared the sample adequacy suspects outcomes and provider perception, regardless of the age, among all COVID-19 suspects who underwent nasopharyngeal (NP) and oropharyngeal (OP) swab procedures. The pediatric suspects below 10 years of age were excluded for reporting of the outcomes. However, data regarding providers preferences and sample adequacy was assessed as per rest of study population.

Administrative approval from concerned authorities and Institutes Ethics Committee (IEC/Pharmac/117/20) is obtained before beginning the study. Suspects willingness to participate in the study, readiness for follow-up, and agreement with the terms of the informed consent were confirmed beforehand.

2.3. Data collection

Data on participant demographic, clinical characteristics, and type of material used for swab collection were collected in a structured proforma. Suspects were enrolled as per the ICMR criteria. The sample registration form was filled to develop system generated unique identity number (ID). Donning and doffing of appropriate personal protective equipment (PPE) is carried out as per guidelines [2]. The sampling is carried out at designated well lighted and ventilated places. The procedure of swab sampling methods was informed to participants individually. Besides, pictorial placards representing appropriate procedure-related information are displayed at the waiting lounge. The swab stick material of Dacron (Fig. 1) or Nylon (Fig. 2) is used for taking the swabs from the NP and OP region.

2.4. Anatomical consideration of sampling

The NP lies at the end of nasal cavities, approximately 10 cm from the anterior nasal spine. Externally this corresponds roughly to the distance between nares and tragus [3]. The sensitive mucosa of the upper airway is highly susceptible to nociception causing discomfort/pain and the mechanical receptors elicits cough reflex upon its stimulation [4]. The presence of spur, deviation of the septum, or hypertrophied turbinate further narrows this space, and rubbing of the swab to these fixed structures may cause significant discomfort.

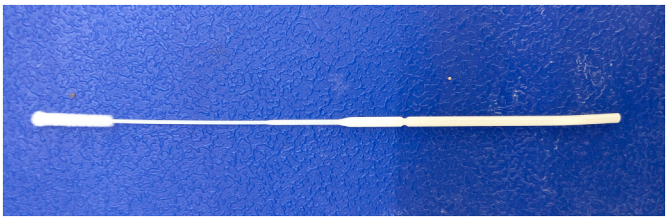

Fig. 1. The Dacron flexible swab stick with a breakpoint at shaft.

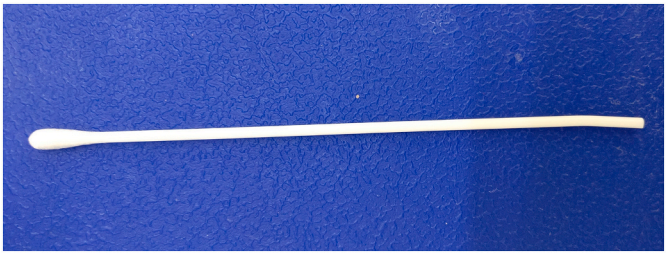

Fig. 2. The Nylon non-flexible swab stick.

The following are the practices undertaken for comfortable and safe sampling without untoward effects.

- Estimation of the depth of the insertion of the swab is done by roughly measuring the distance between the nares and tragus.
- Head extension by 70°.
- Avoiding head movements during the procedure.

2.5. Oropharyngeal (OP) swab

The suspects were asked to sit comfortably and extend his head. The provider stands beside the suspects for the procedure to avoid direct exposure (Fig. 3). Swab head is introduced in OP. It is then rolled several times on the both tonsils/tonsillar pillars and posterior pharyngeal wall. If the suspect is gaging excessively, then the stick is withdrawn partially till he/she is settled downs. At the end the swab stick is dipped in the VTM carrier. Excessive length is cut.

2.6. Nasopharyngeal (NP) swab

A sterile swab stick was introduced in one of the nares. On the perception of fixed obstruction by the performer or excessive discomfort by suspect, the side of the nasal cavity for sampling is changed to the opposite side. Swab stick was passed preferably along the inferior meatus till fixed resistance of NP is encountered. The swab stick was rolled several times and removed gently. The labeled VTM carrier tube is used to store the NP swab stick. The cap of the tube is carefully sealed with paraffin tape and secured to avoid cross-contamination by spillage.

The suspect is asked to wear a mask and answer to note down perceived outcomes. The data is entered by technician. The provider rated experience of the procedure either as no/minimal resistance or significant resistance experienced during the NP swab procedure are noted. In addition, the facial expression of minimal gag or obvious vomiting like expressions of suspect also noted. Suspect's response to the procedure is recorded as mild pain/discomfort (0-5) or moderate to severe pain (6–10). The staining of the swab stick is noted for any blood smearing along with secretions. The data for the adequacy of the sample

Fig. 3. The side by the position of provider health care worker (HCW).

is collected from the laboratory. Sample is deemed inadequate, if the specimen fails to generate fluorescent amplification plot with internal control RNase P gene.

2.7. Storage

The labeled and sealed VTM having the swabs is stored vertically in a thermostable biohazard carrier having ice packs. The temperature of 2 to 6 degrees centigrade is maintained. The carriers were opened only at the molecular diagnostic facility under supervision for analysis by qualitative reverse transcription-polymerase chain reaction (RT-PCR).

2.8. Statistical analysis procedure

All data were entered in a Microsoft Excel spreadsheet and analyzed using EpiData Software. Characteristics of the COVID-19 suspects such as gender and age group, type of swab used in sample collection, and COVID-19 status are summarized as frequencies and percentages. Similarly, the outcome of sample collection, namely sample adequacy, evidence of nasal bleeding, suspect comfort level, and provider experience, are summarized as percentages. Proportions of post sampling outcomes across Nylon and Dacron swabs are compared using the Chi-square test, and they are presented as Adjusted Relative risks (adjusted for suspects age and gender) with a 95% Confidence interval. The comfort level of suspects and providers also were compared across gender and age groups. Statistical significance was considered at less than 0.05 level.

3. Results

3.1. Participant characteristics

One thousand and eight suspects who are subjected to sampling procedures at quarantine centers in 3 months (April - June) are included for study. In these 1008 COVID-19 suspects, 515 (51.1%) were males, and 40% were between the age group of 20 to 39 years (Table 1).

3.2. Types of swab sticks used

Dacron and Nylon swab sticks are used for taking 530 (52.6%) and 478 (47.4%) samples, respectively (Table 1).

3.3. Sample adequacy

Both material were equally effective for taking the swab; there was no statistically significant difference for sample adequacy while using either material [Dacron 511 (96.4); Nylon 454(95), Adj RR (95% CI) 1.40 (0.78–2.52), p=0.26]. A total of 91 (9%) were tested COVID-19 positive among 1008 suspects screened by RT-PCR qualitative assay. There was no statistically significant difference in the COVID-19 positivity rate between flocked Nylon and Dacron swabs [Nylon 51 (10.7%); Dacron 40 (7.5%), p=0.08] (Table 2).

3.4. The suspect and provider grading of the procedure

Provider and suspects grading of the procedure using various parameters were better with the Dacron swab stick compared to Nylon, and the difference proved statistically significant. Suspects who had undergone procedure through Nylon swabs had six times more likely to experience more pain/discomfort compared to suspects where the Dacron swab was used (Adj RR (95% CI: 6.76 (3.53 to 13, p=0.0001))). Similarly, providers also perceived six times more resistance and with the Nylon swabs compared to Dacron Swabs (Adj RR (95% CI: 5.96 (3.88 to 9.14, p=0.0001))) (Table 2). The use of Nylon sticks had a 30% increase in the incidence of nasal bleeding in adults, as evidenced by blood staining in the swab stick compared to the Dacron swabs. [Dacron (25.1%); Nylon (32.8%), Adj RR (95% CI) 1.30 (1.10–1.56); p<0.007] (Table 2). However, the pediatric population had a higher rate of blood staining in Dacron swab compared to Nylon swab [Dacron 66 (80.5%); Nylon 51 (54.8%) p=0.0001] (Table 3).

Perceptions of a team of specialized experts involved in the direct handling of suspects and swab collection are shared regularly during the departmental review.

4. Discussion

As the provider HCW takes up the challenge of steering through the ongoing pandemic of COVID-19, experiences gained at each step are

Table 1
Characteristics of the COVID-19 suspects included for comparing the experience and outcome of different swab type from central India 2020.

Suspect characteristics		Number	Percentage
Gender	Male	515	51.1
	Female	493	48.9
Age group (years)	0–9	175	17.4
	10–19	169	16.8
	20–39	407	40.4
	40–59	190	18.8
	60 or more	67	6.6
Type of swab	Dacron	530	52.6
	Nylon	478	47.4
COVID-19 status	Negative	917	91
	Positive	91	9

Table 2
Comparison of Suspect and Providers related experience and outcome between Nylon and Dacron swabs among COVID-19suspects from central India 2020.

Outcome	Dacron (*n*=530)	Nylon (*n*=478)	Adj. relative risk (95% CI)*	P-value
Blood staining			1.31	**0.007**
Absent	397 (74.9)	321 (67.2)	(1.08–1.59)	
Present	133 (25.1)	157 (32.8)		
Suspects experience			6.56	**0.0001**
Minimal/mild pain Likert (0–5) (792)	448 (98)	344 (87.1)	(3.27–13.15)	
Moderate/severe pain Likert (6–10) (60)	9 (2)	51 (12.9)		
Providers experience			4.57	**0.0001**
No resistance/gag	497 (93.8)	342 (71.5)	(3.19–6.55)	
Obvious resistance/ vomiting	33 (6.2)	136 (28.5)		
Sample adequacy			1.40	0.26
Adequate	511 (96.4)	454 (95)	(0.78–2.52)	
Inadequate	19 (3.6)	24 (5)		

* Relative risk adjusted for age and gender.

Table 3
Distribution of Suspect experience and Provider comfort based on case characteristics among COVID-19 suspects from central India 2020.

Factor	Suspects experience		Providers experience	
	Discomfort Likert (0–5)	Discomfort Likert (6–10)	No resistance/ Minimal gag	Obvious resistance/ Vomiting
Gender				
Female	374 (93)	28 (7)	342 (85.1)	60 (14.9)
Male	418 (92.9)	32 (7.1)	375 (85.3)	75 (16.7)
p-Value	0.91		**0.04**	
Age group				
0–9	26 (63.4)	15 (36.6)	31 (75.6)	10 (24.4)
10–19	136 (88.9)	17 (11.1)	125 (81.7)	28 (18.3)
20–39	381 (94.6)	22 (5.4)	333 (82.4)	71 (17.6)
40–59	184 (96.8)	6 (3.2)	169 (88.9)	21 (11.1)
60 or more	65 (100)	0 (0)	62 (92.5)	5 (7.5)
p value	**0.00001**		**0.03**	

crucial. This study observed better perceived post-procedural comfort among the suspects (98% vs. 87%, $p<0.0001$) and lesser procedural challenges felt by the provider (93.8% Vs. 71.5%, $p<0.0001$) with the Dacron swab compared to the flocked Nylon swab. However, there is no significant difference in virological outcomes in terms of sample adequacy (96.4% Vs. 95%, $p=0.26$) and laboratory positivity rate (10.7% Vs. 7.5%, $p=0.08$) between these two types of the swab.

We did not come across a study which evaluated the performance of different types of swab in the COVID-19 context. However, there are evidences which differentiated the performance of different swabs in case of isolating various bacterial illnesses and Avian Influenza. The study by Dube et al. had demonstrated the higher median Colony Forming Units of isolation with Nylon swabs compared to Dacron swabs [5]. Similarly, Zasada et al. had reported the higher adsorptive and release with the Nylon swab [6]. In another study, the swabs were assessed for both cytology and viral DNA by Gage JC, and colleagues which concluded the need for further studies to determine whether flocked Nylon swabs are better in terms of representing cytological material [7]. The cellular information may not be relevant in COVID-19 diagnosis. However, other factors, such as the comfort to the provider and suspect, adequacy for analyzing specimen are studied in depth.

The magnitude of testing in an ongoing pandemic demands an effective method and use of better material for taking samples from the suspect's respiratory passage. Any repeat sample as a result of inadequate sampling of specimens is an additional burden on the entire system. Sample adequacy in this series was 96.4% with Nylon swab sticks and 95% with Dacron swab sticks. Hence, both performing as equally better material.

The stem of the Dacron swab stick is made of flexible material (silicon) and is provided with a breakpoint for discarding excess length after taking a swab. The breakpoint helps to cut the excess length of the stem without the need to cut it with heavy scissors, which can lead to possible viral aerosol generation. The cylindrical shape of the swab head helps to collect sufficient cytological and viral material as it passes through a narrow nasal cavity in the inferior meatus. The discomfort experienced and smearing of the blood in the adult suspects in case of NP sampling was primarily due to touching of the spurs by the swab sticks. The Dacron sticks having flexible stem upon encountering spur could slip on either side of the spur. Hence, it caused lesser pain to the suspects and reduced chances of blood smearing of the swab.

The procedure of NP swabbing is a blind one; the bulbous ended Nylon swab caused pain in suspects after hitting fixed obstruction by spurs. The non-flexible stem fails to negotiate any such projection without forceful maneuvering. The provider must be aware of the fact that one needs to change the side of the nasal cavity on encountering fixed resistance, which is mostly because of posterior spurs.

The procedure of specimen sample collection from NP and OP is an invasive one and hence known to be potentially aerosol-generating [8]. Alternatively, the salivary secretions studied showed similar sensitivity for diagnosing COVID-19 compared to nasopharyngeal swabs samples [9]. Creating adequate awareness among the community, education regarding self-sampling, adequate availability of collection centers for registration of self-collected samples are few initiatives in this regard are suggested by Adeniji AA et al. [10] In his opinion, this will help in reducing the current burden on HCW and also achieve social distancing by avoiding the gathering of large populations at confined spaces for sample collections. A self-collected salivary sample for COVID-19 testing removes dependence on HCW and the requirement of other infrastructures like PPE and swab sticks. As the salivary secretions have shown almost equal or better results for the detection of COVID-19 infection [11].

The reports of infection of HCW offering their services during a pandemic are already among media circulation, and it is getting noted in the literature [12]. Diligent monitoring is undertaken to identify any cross-infection of HCW at the earliest. The importance of each safety measure needs to be emphasized to the beginner who is performing aerosol-generating procedures. One such step is the practice of side by the position of the provider to the suspect for NP and OP sampling. It prevents direct exposure of the provider to a potential aerosol generation while sampling. In the current study, it was noted that 10% of suspects had facial expressions such as gag and vomiting while taking OP swab.

In about 16% of suspects, the provider felt the obvious resistance inside the nasal cavity while doing the NP swab procedure. And, in around 5% of suspects, need for repeat sampling encountered after inadequate sample as reported by RT-PCR. All these factors can synergistically increase the risk of aerosol generation to a manifold. Self-generated samples can lower this risk as well.

The incidence of COVID-19 in the pediatric population is lower. The sampling in this age group has unique challenges. In a review by Choi et al. data from different countries, including China, Italy, Australia, Singapore, and the Republic of Korea, the incidence of COVID-19 in the pediatric population ranged between 0.5% to 5.2% [13]. It is necessary to inform parents or the caregiver of the child undergoing sampling regarding the whole procedure and the possibility of blood staining of the swab stick. As many anxious parents might raise concern, seeing staining of the swab stick. Keeping the child steady for a brief period is a

difficult task, which is necessary for less traumatic NP swab taking procedure. Unlike Dacron, the bulbous ended flocked Nylon swab stick does not pierce soft adenoid tissues in the pediatric population. Also, children up to the age of 10 years are less likely to have nasal spurs unless some nasal trauma has caused buckling of the septum. Hence, in our experience, flocked Nylon swab sticks are preferable over the Dacron ones in pediatric age suspects. The study report by Christine Wigger et al. also had reported the better comfort experienced with the flocked Nylon swabs among Australian children and their caregivers. However, here they have compared flocked Nylon with the Non flocked Rayon swabs [14].

In this study, we have restricted the virological outcome to sample adequacy and laboratory positivity rate. Though these two swabs could have different absorptive capacity, the magnitude of analyte those were not assessed. With regards to the assessment of patient comfort, in the current study, one particular patient would have undergone the procedure with only one type of swab. The previous studies have assessed the comfort by using two different swabs in the same subjects and analyzed which one they felt more comfortable. Hence, the difference in the distribution of age and gender between these two swabs can influence the reported comfort level. Yet, as we have estimated the relative risk-adjusted for age and gender, the findings are unlikely to be influenced by these factors.

The current study observation recommends the following to adapt to routine practice. First, as the virological outcomes are comparable, provider and suspects comforts are better with a specific type of swab (Dacron); these factors should drive the selection of a specific swab. Second, unlike the adults, children were found to have a lower incidence of events such as bleeding with Nylon swabs. This emphasizes the need for the preferable use of nylon swabs among the pediatric age group. Third, as many of the pediatric age group suspects had evidence of blood staining of the swab, the parents/care providers should be informed prior to alleviate the undue anxiety. Fourth, the incidences of suspects such as gag/vomiting, increased procedural resistance felt by the providers can ultimately lead to unwanted aerosol generation, and potential cross infection among HCW.

5. Conclusions

The bulbous Nylon material caused more pain/discomfort in adults. Given the comparable virological outcomes, the difference in suspect and provider comfort should drive the selection of swab based on characteristics of the suspects. Aerosol generation occurs consistently with cough and sneeze, which can potentially cross infect the provider. Alternate methods of sampling independent of the provider may negate this problem.

References

[1] Kwok KO, Tang A, Wei VWI, Park WH, Yeoh EK, Riley S. Epidemic models of contact tracing: systematic review of transmission studies of severe acute respiratory syndrome and middle east respiratory syndrome. Comput Struct Biotechnol J 2019;17:186–94. https://doi.org/10.1016/j.csbj.2019.01.003.

[2] Centers for Disease Control and Prevention. Interim Guidelines for Collecting, Handling, and Testing Clinical Specimens From Persons for Coronavirus Disease 2019 (COVID-19). Accessed April 16, 2020, https://www.cdc.gov/coronavirus/2019-nCoV/lab/guidelines-clinical-specimens.html; Updated July 8, 2020.

[3] Johnson M, Miskovic A, Ray S, et al. The nasopharyngeal airway: estimation of the nares-to-mandible and nares-to-tragus distance in young children to assess current clinical practice. Resuscitation. 2019;140:50–4. https://doi.org/10.1016/j.resuscitation.2019.04.039.

[4] Polverino M, Polverino F, Fasolino M, Andò F, Alfieri A, De Blasio F. Anatomy and neuro-pathophysiology of the cough reflex arc. Multidiscip Respir Med 2012;7(1):5.

[5] Dube FS, Kaba M, Whittaker E, Zar HJ, Nicol MP. Detection of *Streptococcus pneumoniae* from different types of nasopharyngeal swabs in children. PLoS One 2013;8(6):e68097. https://doi.org/10.1371/journal.pone.0068097.

[6] Zasada AA, Zacharczuk K, Woźnica K, Główka M, Ziółkowski R, Malinowska E. The influence of a swab type on the results of point-of-care tests. AMB Express Mar 12, 2020;10(1):46. https://doi.org/10.1186/s13568-020-00978-9 (PMID: 32166638; PMCID: PMC7067933).

[7] Gage JC, Ghosh A, Borgonovo S, Follansbee S, Wentzensen N, Gravitt PE, et al. A comparison of Dacron versus Flocked nylon swabs for anal cytology specimen collection. Acta Cytol 2011;55(4):364–7. https://doi.org/10.1159/000329488 (Epub 2011 July 22. PMID: 21791907; PMCID: PMC3150956).

[8] Pasomsub E, Watcharananan SP, Boonyawat K, Janchompoo P, Wongtabtim G, Suksuwan W, et al. Saliva sample as a non-invasive specimen for the diagnosis of coronavirus disease 2019: a cross-sectional study. Clin Microbiol Infect May 15, 2020. https://doi.org/10.1016/j.cmi.2020.05.001 (S1198-743X(20)30278-0, Epub ahead of print. PMID: 32422408; PMCID: PMC7227531).

[9] Iwasaki S, Fujisawa S, Nakakubo S, Kamada K, Yamashita Y, Fukumoto T, et al. Comparison of SARS-CoV-2 detection in nasopharyngeal swab and saliva. J Infect Aug 2020;81(2):e145–7. https://doi.org/10.1016/j.jinf.2020.05.071 (Epub 2020 June 4. PMID: 32504740; PMCID: PMC7270800).

[10] Adeniji AA. 'Self-collected upper respiratory tract swabs for COVID-19 test': a feasible way to increase overall testing rate and conserve resources in South Africa. Afr J Prim Health Care Fam Med 2020;12(1):e1–4. https://doi.org/10.4102/phcfm.v12i1.2445.

[11] Wyllie AL, Fournier J, Casanovas-Massana A, et al. Saliva or nasopharyngeal swab specimens for detection of SARS-CoV-2 [published online ahead of print, 2020 August 28]. N Engl J Med 2020. https://doi.org/10.1056/NEJMc2016359.

[12] Castelnuovo P, Turri-Zanoni M, Karligkiotis A, et al. Skull base surgery during the Covid-19 pandemic: the Italian skull base society recommendations. Int Forum Allergy Rhinol 2020. https://doi.org/10.1002/alr.22596.

[13] Choi SH, Kim HW, Kang JM, Kim DH, Cho EY. Epidemiology and clinical features of coronavirus disease 2019 in children. Clin Exp Pediatr Apr 2020;63(4):125–32. https://doi.org/10.3345/cep.2020.00535 (Epub 2020 April 6. PMID: 32252139; PMCID: PMC7170785).

[14] Wigger C, Morris PS, Stevens M, et al. A comparison of flocked nylon swabs and non-flocked rayon swabs for detection of respiratory bacteria in nasopharyngeal carriage in Australian indigenous children. J Microbiol Methods 2019;157:47–9. https://doi.org/10.1016/j.mimet.2018.12.013.